RESTORATION PLAN

for the

BLACKLOCK RESTORATION PROJECT

Suisun Marsh, Solano County, California
SRCD Ownership #635

Prepared By
Division of Environmental Services
California Department of Water Resources

in cooperation with
U.S Bureau of Reclamation
California Department of Fish and Game
U.S. Fish and Wildlife Service
Suisun Resource Conservation District

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List of Acronyms

ADCP	Acoustic Doppler current profiler
BCDC	San Francisco Bay Conservation and Development Commission
BLL	Blacklock water quality monitoring station
BMPs	Best management practices
CBDA	California Bay Delta Authority
CCR	California clapper rail
CDEC	California Data Exchange Center
DEM:	Digital elevation model
DFG	California Department of Fish and Game
DWR	Department of Water Resources
EC	Electrical conductivity
ECAT	Environmental Coordination and Advisory Team
ERP	Ecosystem Restoration Program
FWS	U.S. Fish and Wildlife Service
HDPE	High density polyethylene
MHHW	Mean higher high water
MLLW	Mean lower low water
MSL	Mean sea level
NAVD 88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NOS/COOPS	National Oceanographic and Atmospheric Administration's Ocean Service/Center for Operational Oceanographic Products and Services
OBS	Optical backscatter
PRBO	Point Reyes Bird Observatory
RWQCB	Regional Water Quality Control Board
SCMAD	Solano County Mosquito Abatement District
SET	Sediment erosion table
SMHM	Salt marsh harvest mouse
SMPA	Suisun Marsh Preservation Agreement
SRCD	Suisun Resource Conservation District
SSC	Suspended sediment concentration
TMDL	Total maximum daily load
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geographical Survey

1.0 INTRODUCTION

The Department of Water Resources (DWR), in cooperation with the California Department of Fish and Game (DFG), U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (FWS), and the Suisun Resource Conservation District (SRCD), has prepared this Restoration Plan for the Blacklock site (Figure 1). This Plan describes actions to restore 70 acres of diked, managed marsh to tidal wetlands, using a minimally engineered approach. The project goals and objectives are to 1) restore the area to a fully functioning, self-sustaining marsh ecosystem created through restoration of natural hydrologic, sedimentation and biological processes; 2) increase the area and contiguity of emergent wetlands providing habitat for tidal marsh species; and 3) assist in the recovery of at-risk species.

A Draft Restoration Plan was distributed for review in April 2006. Environmental compliance and permit documentation was initiated during summer 2006 and completed in early October 2006. A conceptual model for the Blacklock Restoration Project is included as Appendix A.

On October 3rd and 4th, 2006, a 61 foot-long breach was constructed in the preferred breach location along Little Honker Bay (station 55+00) (Figure 2). In mid-July 2006, a natural breach occurred at station 52+00. A hole through the levee was identified at this location in January 2006. This breach eroded and deepened over time and is currently approximately 40 feet wide.

Current activities include implementation of a 10-year monitoring program developed for the site. Details of the monitoring program are presented in Section 6.

1.1 Background

DWR received CALFED Ecosystem Restoration Program grant funds in 2001 and acquired this property in December 2003.

This property is identified as SRCD ownership number 635. The grant proposal, *Suisun Marsh Property Acquisition and Habitat Restoration Project*, was prepared and submitted by DWR in 2000 with collaboration from the Suisun Marsh Preservation Agreement (SMPA) Environmental Coordination and Advisory Team (ECAT), which includes DWR, USBR, DFG, SRCD, and FWS. Since Suisun Marsh Mitigation Agreement Funding was identified as the source of cost-share funding for this effort, this became an ECAT project.

The original proposal identified that Phase I (acquisition and pre-project monitoring) and Phase II (restoration plan development) would be completed with the available funds. It was anticipated that additional funding would be required to complete Phase III (environmental documentation and permitting), Phase IV (Implementation of the plan) and Phase V (monitoring). However, the original grant funds, along with the matching cost-share dollars from the SMPA funded the project through implementation.

The existing monitoring program and current level of funding, was designed to meet the terms and conditions of the permits authorizing construction of the levee breach. DWR, in collaboration with the other ECAT agencies, has requested and is expecting to receive additional ERP funds through a Directed Action to implement the first three years of this monitoring program. The remaining years of the required 10 year monitoring program will be funded by the SMPA agencies. The SMPA agencies have agreed to provide $214,000 of SMPA Mitigation Agreement Phase C funds for data collection activities during years 4-10. Project management activities for years 4-10 will be funded by SMPA program funds.

The agencies will continue to seek additional sources of funding (beyond SMPA) to implement additional monitoring of the site. With additional monitoring, the Blacklock site could provide regionally specific data to inform the design and planning of future restoration efforts in Suisun Marsh including tidal marsh acreage goals described in the *Habitat Management, Preservation, and Restoration Plan for the Suisun Marsh* currently being developed by the Suisun Charter Group.

The plan is organized into the following sections:

Section 1: Introduction and Background

Section 2: Site Description

Section 3: Pre-Implementation Site Conditions

Section 4: Identifying Options for Levee Breach

Section 5: Final Design and Implementation Activities

Section 6: Monitoring

Section 7: References

1.2 Goals and Objectives

The goals and objectives guiding this project are as follows:

Goals: To increase the area of tidal brackish emergent wetlands in Suisun Marsh to aid in the recovery of listed and sensitive species, and (2) acquire scientific knowledge that leads to improved understanding of tidal marsh restoration processes, strategies, and ecological outcomes within Suisun Marsh.

Restoration objectives: To restore the Blacklock property to a self-sustaining functioning brackish tidal marsh by restoring tidal action, reversing subsidence, and promoting establishment of native vegetation and a tidal marsh channel network appropriate to this location within the San Francisco Estuary.

Science objectives: To allow for and encourage collaborative science opportunities in the project design and monitoring phases that supports regional adaptive resource management needs.

1.3 Anticipated Outcomes

Projected outcome scenarios are based on a variety of sources, use of computer models, and review of the literature and evaluation of other restorations within the San Francisco Estuary.

- The site would increase in elevation over time via natural sedimentation processes-mineral sediments moving in from Little Honker Bay and decomposition of vegetation on site.
- Full, unimpeded tidal exchange throughout the site.
- As elevations increase, vegetation will colonize throughout the site.

This restoration represents an opportunity to realize many of the ecosystem benefits that are commonly associated with healthy tidal marsh habitat. Fisheries benefits include providing food resources and/or habitat for delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*) Sacramento splittail (*Pogonichthys macrolepidotus*), Chinook salmon *(Oncorhynchus tshawytscha)* and other aquatic species. Targeted wildlife species include Suisun song sparrow (*Melospiza melodia maxillaris*), marsh wren (*Cistothorus palustris*), black rail (*Laterallus jamaicensis*), common yellowthroat (*Geothlypis trichas*) and other avian species.

Restoration of tidal flows will produce substantial changes to the habitats and biological, physical, and chemical functions of the site. Since tidal inundation, the site is a mix of shallow open water with remnant emergent vegetation during much of the tidal cycle, and exposed pond bottom and remnant vegetation during low tides (Figure 3). Over time, the expectation is that the emergent vegetation will colonize the area formerly dominated with saltgrass *(Distichlis spicata)* and pickleweed (*Salicornia virginica)*, until elevations at the site increase enough to support a more diverse array of species.

A new tidal channel network is expected to form, partially re-occupying existing remnant channels partially forming new channels within the newly forming tidal marsh surface. Vegetation will transition to a mix of species suited to the intertidal brackish environment, with the shallow pond bottoms becoming fully vegetated. The deeper ponded areas of the property will likely remain open water areas in the long term.

Knowledge expected to be gained from this restoration includes, but is not limited to, rates of sedimentation and marsh development, the role of existing emergent vegetation in influencing sedimentation, channel network formation and overall geomorphology, hydrology, water quality impacts, methyl mercury production, and species use. Results will inform scientists and decision makers in long-term land use and restoration planning throughout Suisun Marsh.

1.4 Organizational Structure

Because of the collaborative structure of ECAT, there are several agencies involved in this planning effort. The Project Work Team (Appendix B) is comprised of those participating, or who have participated in, a hands-on effort on this project. While DWR is doing the majority of the data collection and project management, other agencies, institutions and individuals are represented on this team. The Advisory Team (Appendix C) is comprised of staff from each ECAT agency, and other individuals providing technical expertise and agency review on the project. The role of the Advisory Team is to make recommendations to the SMPA Coordinators, identified as the decision makers. The SMPA Coordinators are an established group comprised of managers from each SMPA agency (DWR, DFG, USBR, SRCD). Staff at DWR, Division of Environmental Services is responsible for Project Management for the Blacklock Restoration Project.

Comments from reviewers during the grant selection and approval process suggested that the team needed to include independent, qualified individuals with expertise in tidal marsh restoration in the region. DWR contracted with Leonard Sklar, Professor of GeoSciences at San Francisco State University to collect sediment transport data in support of restoration plan development. Point Reyes Bird Observatory (PRBO) Conservation Science conducted avian monitoring of the site. Stuart Siegel, Principal of Wetlands and Water Resources was identified as the Science Advisor. In an advisory role, Dr. Siegel has assisted in project development, review of sediment transport data, hydrologic conditions, geomorphology and other data collected in support of restoration plan development and levee breach design.

1.5 Regulatory Jurisdiction and Compliance

The San Francisco Bay Conservation and Development Commission (BCDC) has jurisdiction over the area as part of the Suisun Marsh Preservation Act. Because this parcel (with the exception of some of the levees) is jurisdictional wetland, the U.S. Army Corps of Engineers (USACE) authorizes work activities under the Section 404 of the Clean Water Act. The Regional Water Quality Control Board (RWQCB) certifies the water quality components under Section 401 of the Clean water Act.

All routine maintenance is authorized under the regional maintenance permit issued by USACE to SRCD and DFG.

DWR is the California Environmental Quality Act (CEQA) lead and USBR is the NEPA lead on this project.

NEPA/CEQA compliance for the acquisition of this property was completed when DWR filed a Notice of Exemption in May 2003 and the USBR published a finding of no significant impact (FONSI) in the Federal Register in November 2003.

DWR prepared an initial study and filed a mitigated negative declaration for project implementation in July, 2006. A Notice of Determination was filed with the State clearinghouse on August 14, 2006. USBR prepared an Environmental Assessment and FONSI in September 2006.

During July through early October, DWR and USBR obtained regulatory authorization to construct breaches along Little Honker Bay and Arnold Slough. Permits obtained for the project included: section 404 nationwide permit 27 issued by USACE; section 401 water quality certification issued by RWQCB; and an administrative permit M06-21 (M) issued by BCDC. In addition, endangered species act (ESA) compliance was received from FWS, National Marine Fisheries Service and DFG. A monitoring plan was developed and approved by BCDC as part of their permit conditions. Details of the monitoring plan are presented in Section 6 (Monitoring).

In 2005, DWR received a nationwide permit No. 5 authorizing installation of a water quality monitoring station (BLL) in Denverton Slough adjacent to the Blacklock site. DWR also received a 401 waiver of water quality certification and BCDC authorization.

An additional nationwide 5 permit was obtained In January 2007, authorizing the installation of the water quality monitoring probe at Blacklock. This probe collects water quality data as required in the 10 year monitoring plan and is part of the BLL station. A CEQA categorical exemption and NEPA categorical exclusion were prepared by DWR and USBR, respectively. DWR is currently in the process of obtaining a 404 water quality certification from the RWQCB.

1.6 CALFED Independent Science Review

CALFED ERP staff facilitated independent science review for the Draft Restoration Plan (April 2006 version). Overall, the reviews were favorable. Recommendations from the three independent science reviewers have been incorporated in this version of the Restoration Plan where appropriate and feasible.

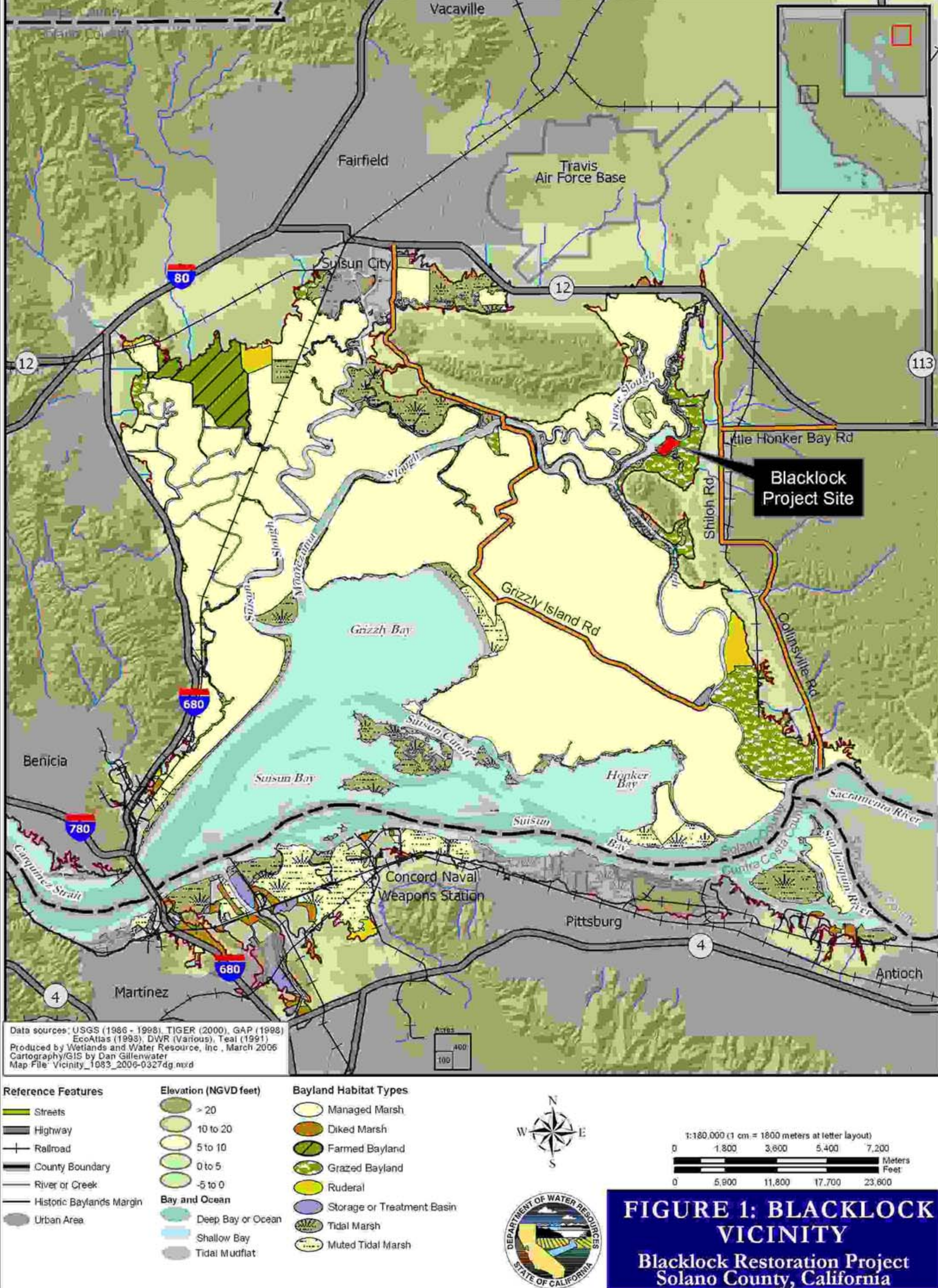


FIGURE 1: BLACKLOCK VICINITY

Blacklock Restoration Project
Solano County, California

Figure 2: 2006 Aerial Photo Showing Breach Locations

Blacklock Restoration Project
Solano County, California

FIGURE 3 – OCTOBER 12, 2006
AERIAL PHOTO
LOOKING SOUTHWEST

Blacklock Restoration Project
Solano County, California

2.0 SITE DESCRIPTION AND HISTORY

2.1 Location and Physical Features

The Blacklock site is located in the northeast Suisun Marsh bordering Little Honker Bay (Figure 1). The parcel is approximately 70 acres, of which about 67 acres are wetland and 3 acres are upland/levee. Prior to tidal inundation, the site features included a diked, managed marsh comprised of a partial remnant network of sloughs, an interior borrow ditch, and seasonally and perennially ponded areas (Figure 4). There is fringing tidal marsh on the outboard side of the exterior levees.

2.2 Adjacent Properties

The restoration site is bordered by one adjacent property located to the east and separated by a 1,100-foot long levee (cross levee), which serves as the property line. The cross levee was elevated in 2004 and 2005 to minimize the possibility of overtopping of waters onto the adjacent property. The one adjacent property, marsh ownership 604, is owned by the Blacklock family and is used for duck hunting and livestock grazing activities. The property contains a diked marsh, primarily vegetated with pickleweed (*Salicornia virginica*), grading to a large expanse of upland grassland. DWR acquired an easement through this parcel when the site was acquired.

Three bodies of water identified as Little Honker Bay, Denverton Slough/Little Honker Slough, and Arnold Slough border the remainder of the site to the west, north, and south, respectively.

2.3 Site History and Land Use

The Blacklock restoration site has been owned and operated by the Blacklock family since 1936, and has been used for livestock grazing and duck hunting activities since 1946 (DWR 2003). The past owner used the entire Blacklock Ranch property primarily for grazing, with some waterfowl hunting in the southwest portion of the Blacklock Ranch including the 70 acres acquired by DWR. Management on the wetland area was minimal, consisting primarily of flooding and circulation during duck hunting season.

The SRCD has developed 11 water management schedule guidelines to assist wetland property owners and managers. The goal of these water management schedules is to optimize the waterfowl forage and cover value. Selection of the appropriate water management schedule is based on location in the Marsh, water control facilities, and water type. Location of a club will determine whether or not its management is affected by endangered species closures. Clubs affected by endangered species closures must restrict or close water intake structures during specific periods to prevent adverse impacts to Chinook salmon and/or delta smelt.

Past club management on the site was variable and did not strictly adhere to any of SRCD's water management schedules. According to Mr. Bill Blacklock (long time owner of the adjacent property), initial flooding of the ponds started in early to mid-October. Ponds were flooded to a maximum depth of 12". Water levels remained static through mid-December at which time the water level was lowered slightly to make invertebrates more easily accessible to feeding waterfowl. Intakes were closed from February 21st through March 31st due to salmon closure requirements. The pond was drained by mid- to late-June and allowed to dry out for cattle grazing. Based on the existing topography and interviews with the owner, disking, ditching and burning on the property were minimal.

Levee maintenance appears to have been minimal and inadequate to protect the property from occasional tidal overtopping. The levees were maintained primarily by borrowing material from the interior toe ditch. It appears that rip-rap was periodically imported to maintain a portion of the exterior levee along Little Honker Bay.

2.4 Interim Management

DWR, with cooperation from SRCD, developed an Interim Management Plan for the property in January 2004. This plan, which identifies several potential management goals proposed for the site, was reviewed and approved by the SMPA Coordinators. An underlying premise of the strategies described in the plan is that during the interim management period, land use at the site would continue to be a seasonal wetland and each of these management goals must be achieved utilizing existing strategies for seasonal wetland management. This plan is available on-line at http://iep.water.ca.gov/suisun/restoration/blacklock/doc/Blacklock.

Upon careful review of the plan, the Advisory Team recommended, and the SMPA Coordinators supported, the interim management strategy to prepare the site for restoration. This management strategy described how to maintain managed wetland in a manner that will not conflict with, and will work towards, the long-term goals of tidal marsh restoration. This management strategy would be achieved by implementing actions that increase vegetation cover at the site prior to breaching. As described in the plan, actions could also incorporate studies evaluating methods for subsidence reversal and, where necessary, substrate modification.

As described in the Interim Management Plan, interim management included moderate water control manipulation, moderate vegetation control and an investigation of techniques for subsidence control and substrate modification. The plan identified advantages of this strategy to include: 1) consistency with the long-term goal of tidal marsh recovery, and 2) creation of physical conditions conducive to tidal marsh evolution. This strategy was also seen as a way to inform the larger California Bay Delta Authority (CBDA) goals for tidal wetland restoration in Suisun Marsh.

In implementing this strategy, DWR manipulated water on the site through the existing 36-inch culvert to encourage the growth of emergent vegetation and allow for circulation throughout the property. In late summer of both 2004 and 2005, the pond was drained (to the extent possible) to allow for construction work on the cross levee (described in section 3.3.1). Once levee construction was completed, the property was re-flooded to previous levels.

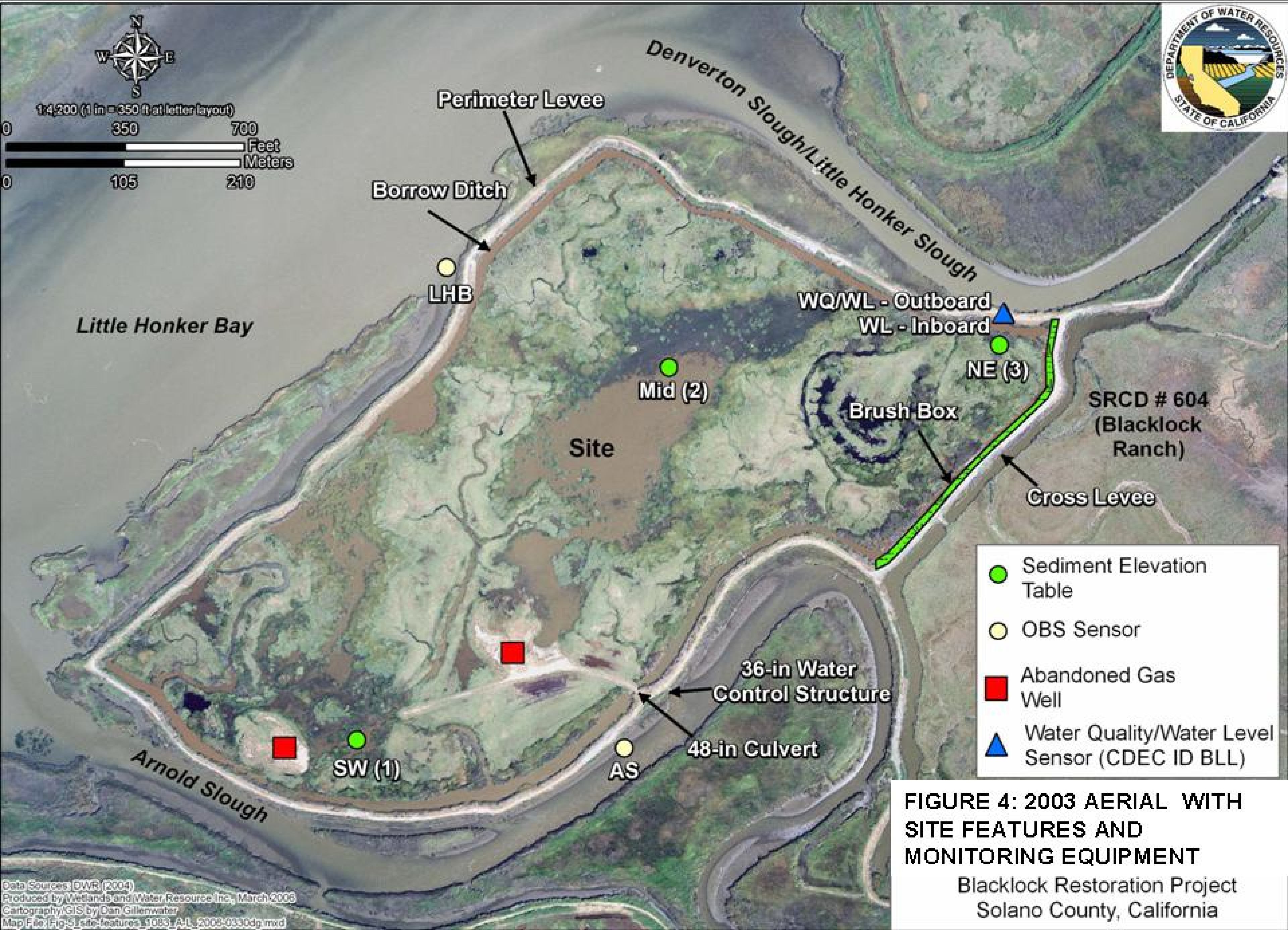


FIGURE 4: 2003 AERIAL WITH SITE FEATURES AND MONITORING EQUIPMENT

Blacklock Restoration Project
Solano County, California

3.0 EXISTING SITE CONDITIONS

3.1 Physical Features

3.1.1 Topography

DWR conducted a field elevation survey of the site in August 2002. Figure 5 shows the digital elevation model (DEM) created by DWR and updated by WWR using the topographic data. Elevations at the site range from approximately -1.9 feet up to 9.2 feet (NAVD 88). With the exception of the levees and one of the abandoned gas wells, most of the property is subsided. The mean sea level at this location is approximately 4 feet. Additional elevation surveys were conducted on the perimeter borrow ditch and slough network during 2005.

3.1.2 Soils

The U.S. Department of Agriculture soil survey for Solano County (USDA 1975) shows only two soil types at the site. The area inside the levee is Tamba Mucky Clay, and Tidal Marsh soils are present outside the levees.

The Tamba soil series consists of very poorly drained, fine-textured soils with a high organic matter component. The soils occupy nearly level salt and brackish water marshes and are formed in mixed alluvium from mixed sources and hydrophytic plant remains. In a typical profile, the mucky clay extends to a depth of more than five feet.

This very poorly drained soil is moderately permeable. The surface runoff is ponded and the erosion hazard is slight to none. The total available water holding capacity is 3-5 inches. The effective rooting depth is shallow and the soil has low fertility. Areas with this type of soil association are typically used for wildlife habitat, recreation (irrigated duck ponds) and grazing.

The tidal marsh soil is a very wet, poorly drained, and strongly saline soil type that has unobstructed access to tidal water. This land ranges from unvegetated mud flats that are inundated daily by tidal flow to a mixture of hydrophytic plant remains and alluvium that is covered by water only at high tide and are (at this site) thickly vegetated with *Schoenoplectus bolboschoenus* and *Typha*. Permeability and runoff rates are low with these soils. Effective rooting depth is very shallow and fertility is very low. This land type is used for wildlife habitat and recreational uses. (USDA, 1975)

3.1.3 Hydrology

Because of the location and relative isolation of the parcel, there are no watershed inflows to affect the hydrology of the site, except under the extreme tidal/flooding scenarios which occurred in 1998, 2005 and 2006. Tidal inundation, as described below, along with site elevation, has the greatest influence on the development of a fully functioning tidal marsh.

Prior to construction of the levee breach, the Blacklock parcel has been flooded since late December 2005. The flooding was due to overtopping of the levees at high tides and seepage through the levee in several locations. Weather and Delta outflows during winter 2006 resulted in higher than normal tides throughout Suisun Marsh, sometimes 1-2 feet above predicted levels. An aerial photo taken of the site in June 2006 (Figure 2) shows the site conditions due to overtopping and seepage through the levees. This photo was taken prior to the levee breaches (natural or constructed). In July 2006, a hole through the levee at stn 52+00 expanded, which resulted in muted tidal conditions at the site.

Water Control
When managed as a seasonal wetland for waterfowl, a 36-inch water control structure was used for both flooding and draining the property (Figure 4). The structure consists of a corrugated metal pipe with a screw-flap gate on the slough side and a winch flap gate on the interior side. The gate was installed in the summer of 1998 and was in good working order. There is also a 48-inch pipe under the road to the well pad to allow circulation in the borrow ditch that runs along the interior toe of the levees. This culvert under the road was replaced with high density polyethylene (HDPE) pipe in August 2005. A flashboard riser was installed on the west side of the pipe, which can be closed to reduce circulation in the perimeter borrow ditch.

Tidal Datum Reckoning
DWR contracted with the National Oceanographic and Atmospheric Administration's Ocean Service / Center for Operational Oceanographic Products and Services (NOS/CO-OPS) to install a water level observation gauge on Bradmoor Island in 2004 where it had previously operated a station in the 1970's (Station ID NOS 941-4811). The purpose of the gauge is to determine the tidal datum (heights and range of the tides) for the Nurse Slough/Denverton Slough complex in the northeast Marsh, in the vicinity of the Blacklock property. The project included installation of two geodetic benchmarks to augment three existing benchmarks.

NOS/COOPS uses these data to update tidal datum and tide predictions for this station. NOS/COOPS agreed to install and operate the tide gauge for a minimum of one-year and to use recently developed tidal datum calculation standards (NOAA 2003) to update the tidal datum at the Bradmoor station site. Five benchmarks are required to meet survey standards; three historical benchmarks currently exist at the site. Elevations of all five benchmarks were checked during water level instrument installation (April 2004), and after 6-months. NOAA removed the gauge in April 2006.

NOS/COOPS processed the data and computed a preliminary 4-month (April through July, 2004) tidal datum (Table 1). Several height statistics are represented including mean higher high water (MHHW), mean sea level (MSL), and mean lower low water (MLLW). All heights are referenced to the North American Vertical Datum of 1988 (NAVD 88). NOS/COOPS will provide a final report on the tidal datum elevations and the geodetic datum relationships to DWR when available. All preliminary and verified data obtained from the Bradmoor station is available on a real-time basis via the NOS website at http://tidesonline.nos.noaa.gov/.

A water quality monitoring station was installed at the northeast corner of the Blacklock property in 2005 (Figure 4). This station monitors tide stage, electrical conductivity (EC) and temperature in Denverton /Little Honker Slough. The station also monitors precipitation, wind speed and direction. In addition, a pressure transducer was installed in the borrow ditch of the Blacklock property to monitor interior water levels. This sensor provides data on the extent of tidal inundation. This station is identified as BLL on the California Data Exchange Center (CDEC) network. Hourly data is available on-line at http://cdec2.water.ca.gov/cgi-progs/queryFx?s=bll.

Table 1 shows the stage at the Bradmoor Island gage. Stage at the Blacklock gage is tending to be a few centimeters higher than Bradmoor at high tide.

Table 1 - Tidal Datum Diagram of Bradmoor Island Tides

NAVD88 Tidal Datum Diagram for Bradmoor Island Tides

	Meters	**Feet**
Gas well BM on Blacklock concrete pad	2.350	7.71
MHHW	1.956	6.418
MHW	1.797	5.896
* PBM 4811 C 1978	1.766	
MSL	1.170	3.834
MTL	1.154	3.786
MLW	0.511	1.677
MLLW	0.283	0.929

Preliminary Bradmoor Is. Tidal Datum (MHHW to MLLW)

Preliminary data based on 4 months of data collected from April - July 2004
*** Primary Bradmoor Bench Mark**
Gas well BM tied to GPS network station BR2 near Mr. Blacklock's dock (7.01 ft NAVD88). GPS elevation of Gas well resurveyed in 2005 by WWR.

<u>Existing Slough Network</u>

As shown on the 2003 aerial photo, a remnant historic tidal marsh slough network still exists on the site (Figure 4). To supplement the original elevation survey conducted in 2002, additional surveys of many of the remnant tidal sloughs were conducted in March 2005. These remnant sloughs range in width from 5 to 15 feet and in depth from ½ to 2 feet across the site. In addition, there is a perimeter borrow ditch around the property along the interior toe of the exterior levee. While the property was a seasonal wetland managed for waterfowl, material was removed from this ditch and used to maintain the levees. An elevation survey of this ditch was conducted in 2005. The width of the borrow ditch varies from approximately 10 feet to 35 feet and extends into ponded areas at several locations throughout the parcel.

3.1.4 Suspended Sediment Concentration

<u>Methods</u>

In-situ suspended sediment sampling was carried out at two locations outside the Blacklock site at Little Honker Bay and Arnold Slough (Figure 4). Little Honker Bay, west of the site, is a small open water body. Arnold Slough, south of the site is a narrow slough channel. At each location, a D&A Instruments OBS-3 sensor connected to an OWL2c data logger was mounted 0.9 feet above the substrate. Approximately every two weeks the OBS sensor was cleaned, data from the datalogger downloaded, and batteries exchanged. The sensor at Arnold Slough was deployed from December 21, 2004 to January 4, 2006. The Little Honker Bay sensor was deployed December 21, 2004 and removed during spring 2006.

OBS readings were taken once every 12 minutes (or 15 minutes for a few deployments) to correspond with the NOS tidal gauge at the nearby Bradmoor Island station. Each sample burst consisted of 64 samples at 0.1Hz. The data logger recorded date, time, battery voltage, and OBS minimum, maximum, average, and standard deviation.

The OBS sensors were calibrated in the field using four different concentrations of field sediment/water samples. The actual sediment concentration of the calibration samples was analyzed in the laboratory using the ASTM standard D

3977 – 97, “Standard Test Methods for Determining Sediment Concentration in Water Samples”. “Method B-Filtration” was used for all samples collected.

Data was filtered for a number of factors that were thought to cause unsound data. First, errant data due to the logger taking readings when the sensor was out of the water for maintenance at the start and end of each deployment were filtered. Second, records portraying a low battery status (less than 9.7v) were filtered out. Third, data was filtered out each time the water surface was within 1.0 feet of the sensor head (as determined by the NOS Bradmoor Island tidal records) as the OBS sensor reports errant readings from ambient light. Lastly, to remove data flyers, a difference from the running mean (one hour before and after) was calculated and any data with greater than a 20 percent difference was filtered out.

Due to the combination of sediment and algae collecting on the optical surfaces of the OBS sensors, data drift was apparent and corrected for using fitted curves based on the difference in readings pre- and post-cleaning.

Results

Suspended sediment concentration (SSC, milligrams per liter or mg/L) results are shown in Figure 6. Results are shown separately for Little Honker Bay and Arnold Slough, and the difference in magnitude of the 2-hour running mean between the two stations is also shown in order to illustrate differences between the two locations.

At Little Honker Bay, concentrations ranged from a low of about 20 mg/L to nearly 500 mg/L, with most values being less than 200 mg/L. Data shows a small spring-neap tide cycle signal. SSC tended to be higher in the winter and spring months and lowest in the fall months. At Arnold Slough, concentrations ranged from a low of about 30 mg/L to a high of about 430 mg/L, with most values being less than 150 mg/L. Arnold Slough shows the same seasonal pattern observed at Little Honker Bay.

The SSC difference between the two stations shows greater SSC values at Little Honker Bay during winter, spring and summer months, with the difference ranging from 10-30 mg/L commonly and in some instances up to 200 mg/L. Values were higher at Arnold Slough during the fall, by about 10-20 mg/L typically.

These results provide two beneficial pieces of information. First, they indicate that a reasonable sediment supply exists to support natural sedimentation within the Blacklock site. The values observed are within commonly seen ranges elsewhere in the San Francisco Estuary where natural sedimentation is known to occur in tidal marsh restoration sites (PWA and Faber 2004). With this information, monitoring of sediment accretion at the SET locations will inform us as to rates of sediment accretion at specific locations. This is the first site in Suisun that accretion rates will be quantified. Second, these data can support sediment transport modeling that DWR may undertake (pending additional funding for this activity) after project construction to develop more insight into physical processes promoting tidal marsh restoration in Suisun. Sediment transport modeling, supported by actual data collected, will provide estimates of sediment accretion rates throughout the property.

A sediment transport modeling study is a crucial part of the study of the restoration processes in Blacklock. This is because sediment transport and accretion are fundamental to wetland restoration: Wetland can be rebuilt only if there are abundant sediment supply and a favorable hydrodynamic and sediment transport pattern for sediment accretion. Therefore, questions that relate to the source and the quantity of sediment (e.g., where the sediment comes from and if there is enough quantity to rebuild the wetland), the nature of sediment transport (e.g., how sediment concentration is distributed spatially and how it varies with time when a restoration action such as a levee breach is made), and the erosion and deposition potential (e.g., whether erosion or deposition will occur and if yes, how the erosion and deposition varies spatially and what the erosion and deposition rates will be) are of great concerns to wetland restoration processes. A sediment transport modeling study will provide answers to these questions. In summary, a sediment modeling study in Blacklock is both important and feasible but funding for this activity has not been identified. If and when funding becomes available for such a study, it would also provide necessary experience, knowledge and modeling parameters for future marsh restoration studies in Suisun Marsh.

3.2 Existing Biological Conditions

Except where noted, the following descriptions are related to site conditions prior to tidal inundation, and construction of the levee breach in October 2006.

3.2.1 Regional Biology

The regional biology of the Suisun Marsh is described in general in the Bayland Habitat Goals Report (1999) and the final report prepared in 2001 by the Suisun Ecological Workgroup at the request of the State Water Resources Control Board. This report can be found on line at http://www.iep.ca.gov/suisun_eco_workgroup/final_report/SEWFinalReport.pdf. Most of the Suisun Marsh is diked seasonal wetlands managed for waterfowl habitat. A few tidal marshes remain along Suisun and Cutoff Sloughs (Rush Ranch), Hill Slough, and Peytonia Slough. Marsh ponds exist to a limited extent in low areas of diked baylands.

3.2.2 Ecosystem Types

Prior to tidal inundation, the site was characterized by 3 main ecosystem types: upland, seasonal wetland, and aquatic. The upland areas of the site are restricted to the levees and the abandoned well pad which is concrete. The sloughs and pond areas comprise the aquatic areas of the site; over the past several years, water has remained in the central portion of the site year-round. The majority of the site was managed seasonal wetland. The distribution of vegetation present was primarily a function of the topography on the site and inundation due to water management.

Since tidal inundation, the site is characterized by upland and tidal wetland/aquatic.

3.2.3 Special Status Species

A list of sensitive species of wildlife and plants that are known to occur in the vicinity of the Blacklock Restoration site is provided in Appendix D. No special status species of plants have been observed within the project boundaries but several including Masons liliaopsis (*Liliaeopsis masonii*), Suisun Marsh aster (*Aster lentus*), Suisun thistle (*Cirsium hydrophilum var hydrophilum*), Delta tule pea (*Lathyrus jepsonii var jepsonii*), soft bird's-beak (*Cordylanthus mollis mollis*) and Contra Costa goldfields (*Lasthenia conjuguens*) are found in the Suisun Marsh.

With the exception of the State and federally listed salt marsh harvest mouse (SMHM) (*Reithrodontomys raviventris halicoetes*), and Suisun song sparrow (*Melospiza melodia maxillareies*), no sensitive wildlife species have been observed within the project area. The results of SMHM surveys are described below in section 3.2.7. Bird surveys are described in Section 3.2.6 below. Surveys for California black rail (*Laterallus jamaicensis coturniculus*) are ongoing.

3.2.4 Vegetation

The DFG, Wildlife Habitat Division conducted a comprehensive vegetation survey of Suisun Marsh in 1999. Change detection surveys were conducted in 2000, 2003 and 2006. The 2006 change detection data is not available yet. Figure 7 shows the Blacklock portion of the resulting vegetation map representing conditions in June 2003. Prior to inundation vegetation in the wetland consisted primarily of tules (*Shoenoplectus acutus*), cattails (*Typha*) and saltgrass (*Distichlis spicata*), with some waterfowl food plants such as brass buttons (*Cotula coronopifolia*) and alkali bulrush *(Bolboschoenus maritimus)*. Vegetation along the levee includes native rose (*Rosa californica*), blackberry (*Rubus discolor*), and annual grasses. With the site inundated since January 2006, only emergent vegetation is visible; salt grass and pickleweed were submerged (Figure 2). Under tidal conditions, emergent vegetation (*Typha,* *Schoenoplectus (Scirpus)* and *Phragmites* dominate the vegetation at the site with the pickleweed and salt grass areas exposed at low tide.

3.2.5 Aquatic Species

Three locations (Figure 8) were beach seined on August 25, 2004 to evaluate pre-project fish presence and diversity. At the sites seined, water depth varied from 0.3 to 3.0 feet. Seining was done days before the culvert was re-opened following the end of the Chinook salmon closure period. Three locations were chosen for sampling according to a likelihood of catch and for their accessibility. A beach seine was used to span the channel and corral fishes present to the bank where individuals were placed into a holding bucket for identification.

Native and introduced species were captured at all three locations. Native fishes caught include tule perch (*Hysterocarpus traskii traskii),* prickly sculpin (*Cottus asper*), three-spine stickleback (*Gasterosteus aculeatus)* and Sacramento blackfish (*Orthodon microlepidotus*). Black crappie (*Pomoxis negromaculatus)*, Shimofuri goby (*Tridentiger bifasciatus*), inland silverside (*Menida beryllina*), mosquito fish (*Gambusia affinis*), brown bullhead (*Ictalurus nebulosus*), carp (*Cyprinus carpio*) and American shad (*Alosa sapidissima*) comprised the introduced species sampled. Temperature, dissolved oxygen (DO) and electrical conductivity (EC) were recorded prior to seining for each site. Numerous *Palaeomon* shrimp, crayfish and other invertebrates were also observed. Table 2 shows the results of the 2004 survey.

Table 2 - Fish sampling results

Native Species		Sampling locations as shown on Figure 8
Tule perch	*Hysterocarpus traski*	3
Prickly sculpin	*Cottus asper*	1,2
Three-spine stickleback	*Gasterosteus aculeatus*	1
Sacramento blackfish	*Orthodon microlepidotus*	3
Introduced Species		
Black crappie	*Pomoxis nigromaculatus*	1,2,3
Shimofuri goby	*Tridentiger bifasciatus*	1,2
Inland silverside	*Menidia beryllina*	2,3
Mosquito fish	*Gambusia affinis*	1,2,3
Brown bullhead or Black bullhead	*Ameiurus nebulosus* *Ameiurus melas*	3
Carp	*Cyprinus carpio*	2
American shad	*Alosa sapidissima*	3
Invertebrates		
shrimp	*Palaeomon*	1,3
Crayfish		3
Others		1,2,3

From DWR fisheries sampling August 25, 2004
1) borrow ditch on SE side of property, and NE side of well road culvert near diversion intake structure
2) first-order slough from borrow ditch (south of well pad) to 20 feet interior;
3) borrow ditch at NE corner of site from corner to 25 feet to the SW.

3.2.6 Birds

PRBO Conservation Science (PRBO) biologists conducted a variety of surveys at the Blacklock restoration site, periodically through the annual cycle, from spring 2004 to fall 2006. In addition, PRBO conducted avian surveys at additional sites in the vicinity of the Blacklock site. Surveys were conducted at two nearby sites: a managed, seasonal marsh located on the Delta King Ranch and a fringing tidal marsh on the Overlook property neighboring Blacklock ranch (Figure 8). The Overlook site was intended to serve in part as a "reference" site, indicative of the future tidal marsh habitat to be developed as a result of the Blacklock restoration project. A fourth site, Rush Ranch, was surveyed in spring 2004 and spring 2005; this site was chosen as a good example of the target tidal marsh habitat in a site that is more comparable in size and configuration to the Blacklock site and therefore can serve as a good reference site.

Objectives of the project addressed by this study include:

- What are the impacts to avian species of converting seasonal, managed wetlands to tidal marsh? Which species can be expected to be more prevalent and which species less prevalent as a result of this habitat change?
- How does the pattern of habitat use (e.g., seasonally) by birds change as a result of habitat change?
- What are the characteristics of restored tidal marsh habitat and the surrounding landscape, as applied to Suisun Marsh, that maximize its wildlife value to birds?

To address these questions, variable-distance point count surveys were conducted once a season (fall, winter) or twice a season (early spring, late spring; no surveys during summer) at each site. This type of survey provides an index of abundance for each species and information on species composition, and is the survey method best suited for passerines and other "landbirds." A second type of survey, area surveys (also termed "line-transect surveys") was carried out at the less vegetated Delta King and Blacklock sites. This type of survey provides an index of bird abundance and provides information on non-passerines such as waterfowl, shorebirds, and herons and egrets (though these groups are also surveyed by point counts). The behavior and micro-habitat utilization of the birds was also recorded with area surveys.

Survey locations at Blacklock are shown on Figure 8. California black rails were surveyed in the spring of 2005 at the three Blacklock-vicinity sites; these species-specific surveys are conducted twice during the breeding season. This State-threatened subspecies is highly secretive but very vocal, especially when taped calls are played back. A fourth survey, specifically for California clapper rails (CCR) (*Rallus longirostris obsoletus*) was conducted in the area surrounding Rush Ranch. CCR surveys were not not conducted in the vicinity of Blacklock because the property in not in within the critical habitat of this species. Marshwide surveys for CCR do not extend this far east. Protocols for all surveys used were consistent with those developed as part of the San Francisco Estuary Wetlands Regional Monitoring Program (San Francisco Estuary Wetlands Regional Monitoring Program 2002; www.wrmp.org).

Species richness was moderately high at the Blacklock site with 27 different species present at the site including Suisun song sparrow, marsh wren (*Cistothorus palustris*), and common yellowthroat (*Geothlypis trichas*). These three species or subspecies are mainly dependent on tidal-marsh habitat, though they may also use habitat with limited tidal flow, provided the appropriate vegetation is present. During the breeding season, bird use at the Blacklock site was limited: only 12 species were detected. In contrast, the Overlook site displayed higher species richness throughout the year (33 species detected) and specifically during the breeding season (16 species detected). The Rush Ranch site, where surveys were conducted during the breeding season only, demonstrated 15 species.

One difference between the Blacklock pre-restoration site and the two tidal marsh sites (Overlook and Rush Ranch) is the higher abundance of common yellowthroats and Black Rails at the tidal marsh sites, especially at Rush Ranch. For example, Black Rail Surveys at Rush Ranch in 2001 (the last year conducted there) revealed detections of this species at 6 out of 10 survey stations. At the Blacklock site, there were detections at only 2 of the 10 survey stations.

Similarly, common yellowthroats displayed high abundance at Rush Ranch, almost equal to that of marsh wrens, whereas this was not the case at the Blacklock site. Studies conducted in San Pablo Bay and Suisun Bay by PRBO biologists demonstrated that common yellowthroats are present at marshes of all ages but that their abundance increases with marsh age, thus, on average, ancient tidal marshes displayed the highest density and young restoration sites the lowest density (Nur et al. 2004)

In addition, the study demonstrated the value of managed marsh as bird habitat. The Delta King site demonstrated a species richness of 48 species over the course of 1 year and 29 species detected during the breeding season, values that are about twice that observed at the Blacklock site and also substantially greater than at the tidal marsh sites. Dabbling ducks are one species group that benefits from managed marsh habitat, and to an extent, piscivorous birds do as well (such as gulls, terns, herons, and egrets).

3.2.7 Salt marsh harvest mouse

The SMHM is a federal and State endangered species endemic to the brackish and salt water marshes around the San Francisco Bay Estuary. There are two subspecies, and it is the northern subspecies, (*R.r. haliocetes*), that is found in the Suisun Marsh. DWR conducted SMHM surveys in 2003, 2004 and 2005. Each survey was done using Sherman live traps, which were opened for four consecutive nights.

In 2003 two areas of the pond were surveyed: Grid Pond 1 in the NE pond where vegetation is primarily salt grass (*Distichlis spicata*) and fat hen (*Atriplex triangularis*), and grids 2 and 2a in the SE pond near the well pad, which is primarily pickleweed (*Salicornia virginica*). A total of 105 traps were set, and SMHM were captured only in the area around the well pad.

In 2004, surveys were conducted in the two areas surveyed in 2003 (grids Pond 1, 2 and 2a) and five additional areas, including three areas along the exterior levee (Pond 3, 4, 4a and Levee 1, 2 and 3). A total of 108 traps were set for four consecutive nights. Vegetation at the levee sites was primarily *Schoenoplectus* and *Typha*, and except for the area near the well pad (Grids 2 and 2a), which was primarily pickleweed, the pond sites were primarily salt grass.

In 2005, six areas were surveyed: grids Pond 1, 2, 3, 5 and Levee 1 and 2. The only new area was Pond 5, located in the southwest corner of the pond in an area vegetated with tall emergents such as *Typha* and *Schoenoplectus*. Survey results are in Table 3 and the survey sites shown on Figure 8.

Similar SMHM surveys were not conducted during 2006 because there was no suitable habitat within the pond due to flooded conditions. Overtopping from high tides and holes in the levee resulted in the pond being inundated with 1-2 feet of water since January 2006. All of the SMHM habitat within the pond was inundated.

Prior to construction of the levee breach, SMHM surveys were conducted near stn 55+00 along Little Honker Bay. No SMHM were trapped in 5 trap nights. Immediately upon completion of the surveys, the vegetation was removed along the location of the constructed levee breach as per conditions of the regulatory permits for construction.

Table 3 - SMHM Survey results by grid at Blacklock, 2003-2005

Grid	2003 # traps	2003 Results[1]	2004 # traps	2004 Results	2005 # traps	2005 Results
Pond 1	30	1 WHM	20	3 UNHM, 2 WHM	15	1 WHM
Pond 2	53	7 SMHM	15	2 UNHM, 2 WHM	18	
Pond 2a	22	5 SMHM	7	1 WHM	N/A	
Pond 3	N/A		15	2 SMHM, 3 UNHM, 2 WHM	11	1 SMHM
Pond 4	N/A		8		N/A	
Pond 4a	N/A		10		N/A	
Pond 5	N/A		N/A		16	1 SMHM, 1 UNHM, 3 WHM
Levee 1	N/A		14	2 SMHM, 2 WHM	20	2 UNHM, 3 WHM
Levee 2	N/A		10	3 SMHM, 2 UNHM, 2 WHM	20	1 SMHM, 4 UNHM, 5 WHM
Levee 3	N/A		9	1 WHM	N/A	

1/ SMHM=salt marsh harvest mouse; UNHM=unknown harvest mouse, morphological characters between those of SMHM and WHM; WHM=western harvest mouse, *Reithrodontomys megalotis*.

3.3 Historical and Cultural Resources

A search of the records maintained at the Northwest Information Center of the California Historical Resources Information System at Sonoma State University did not identify any previously recorded cultural resources in the project area or vicinity, nor have any cultural resources studies previously been conducted in the project area. Contact with the Native American Heritage Commission and local Native American representatives failed to identify the presence of any traditional cultural properties or sacred sites within the proposed project acreage.

In September 2006, USBR consulted with the State Office of Historic regarding the potential impacts to historic properties from the restoration of this property to tidal wetlands. The State Office of Historic preservation conducted a review of the property and determined that this property, and the exterior levees are not eligible for the National Register of Historic Preservation pursuant to any of the eligibility criteria found under 36 CFR 60.4, nor do they retain integrity to their potential period of significance as part of the initial effort to reclaim wetlands for agricultural purposes in the 1850s to the 1860s. They concluded that the proposed project to restore the property to a tidal marsh would not have an effect on historic properties pursuant to 36 CFR 800.4(d)(1).

3.4 Constraints

3.4.1 Adjacent Subsided Lands

The property includes approximately 1.5 miles of levees consisting of 1.3 miles of exterior levees and approximately 0.2 miles of an interior “cross” levee. The exterior levees are along Little Honker Bay or adjacent sloughs. DWR surveys conducted during summer 2004 indicate the elevations of the exterior levees range between 6.4 and 9.2 feet NAVD, with an error of 0.5 foot. Overtopping of the levee occurs in several locations during high tides. Figure 9 shows the locations where the levee is less than 7 feet NAVD and susceptible to overtopping in high tides. The width of the levee crown is variable, ranging from 6 to 10 feet.

During 2003 and 2004, DWR maintenance crews made repairs to the erosion area at stn. 47+00 (Figure 10) but the repairs did not hold. Significant damage occurred in several locations during the December 2004 - January 2005 high tides, and again during the January 2006 storm event. A California Conservation Crew placed visquine and sandbags in three of the more severely eroded locations during January 2005 to prevent further erosion to these sites (Figure 10). (Prior to breach construction, the visquine was removed.) Continued overtopping at this site, and others has resulted in erosion of the pondside levee slope and crown of the levee. Since early 2005, it has not been possible to safely drive a vehicle around the exterior levee as the crown roadway is less than 6 feet in some areas.

DWR environmental and engineering staff evaluated the severely eroded levee sections and determined that it was likely that the levee would breach in one or more of these locations unless significant and costly repairs were made. DWR and ECAT agency staff agreed that funding was not available to complete major repairs on the levee in these sections. In May 2005 the Advisory Team recommended, and the SMPA Coordinators agreed, to forgo additional costly repairs to the severely eroded levee sections and instead, develop the restoration plan acknowledging the physical constraints of the property.

On December 12, 2005, DWR staff discovered water flowing through a hole in the levee near stn. 52+00. The hole, near the top of the levee on the Little Honker Bay side of the levee, was approximately 18 inches long and 10 inches wide. There was a “sinkhole” about 6 feet from the crown on the pond side of the levee, approximately 4 feet wide, 6 feet long and 5 feet deep. Material had eroded back towards the crown of the levee from the pond side. Because the hole on the Little Honker Bay side was near the crown of the levee, water only flowed into the site at tides over 5 feet. DWR engineering staff predicted that subsequent high tides would continue to enlarge the hole and erode the levee material, eventually leading to a levee breach in this location. This unintended/natural breach occurred in July 2006.

Another hole was discovered in the levee during January 2006. This hole, located near stn. 14+00 was approximately 5 feet long and 2 feet wide on the levee crown. Levee material had eroded away under the crown from the hole (approximately 2/3 of the way across the levee) towards Arnold Slough. Material remained in place along the north 1/3 of the levee (pond side). This hole was thought to be caused by beaver activity in the area. Because of its proximity to the cross levee, this hole was repaired in April 2006.

<u>Cross-Levee</u>
When the site was acquired in December 2003, there was a short interior levee (~1,100 feet) between the Blacklock property and the adjacent Blacklock Ranch. To protect the adjacent property from flooding in the event of an unplanned levee failure, and minimize DWR’s flood liability when the property was opened to the tides, the cross-levee was raised to 9.0 feet NAVD during 2004. Because the RGP sets limits on the quantity of material each property is allowed to place each year, the levee work continued over two construction seasons. Additional material was placed on the (west) slope during the 2005 construction season to restore a 2:1 side slope to the levee. All material used to raise the levee was imported and the material was tested for contaminants prior to placement. All levee work was authorized under the USACE regional general permit 24215N issued to SRCD and DFG.

To protect the levee slope from wind and wave erosion, brush boxes were installed on the cross-levee slope in early 2006 as an alternative to rip rap. Brush boxes are constructed by driving 2 parallel rows of 3-inch diameter wooden poles along the levee slope. Recycled Christmas trees were placed between the poles and secured in place (Figure 11). This method has been used successfully in other areas of Suisun Marsh and in the Sacramento-San Joaquin Delta.

The base of the cross-levee was revegetated with *Schoenoplectus californicas* in 2005 (Figure 11). This species will remain viable during the winter months. In addition, woody vegetation was planted on the levee slope above the brushboxes. The brushboxes are expected to provide erosion protection for 3-5 years, giving time for the revegetated levee to mature. This alternative approach to protect the levee slope will be evaluated for effectiveness. If the brushboxes do not provide adequate protection, additional measures will be considered.

Under existing conditions, the adjacent Blacklock Ranch floods via overtopping of its levees under extremely high tides. This condition occurred during the January 2006 storm event. This flooding is unrelated to the Blacklock Restoration Project. Therefore, while maintaining the cross levee to maintain existing levels of flood protection was identified as a high priority for this project, the purpose is to maintain existing levels of flood protection provided by the restoration site, and not to protect adjacent lands from any flooding.

3.4.2 Abandoned Gas Wells

The property contains two abandoned gas wells. Blacklock Number One was drilled in 1951 and abandoned in 1954. Blacklock Number Two was drilled in 1954 and abandoned in 1972. Both wells were capped and decommissioned according to accepted industry and government standards in 1954 and 1972 respectively (DWR 2003). The wells are classified as being "plugged and abandoned – dry hole" by Weatherford Artificial Lift Systems, Inc., the previous well owner. Weatherford relinquished all rights to Mr. Blacklock in January 2003, and ownership of the wells passed to DWR with purchase of the parcel. No additional work is required on the wells (DWR 2005). The well pad for Blacklock Number One was dismantled and removed from the site; the concrete well pad for Blacklock Number Two is still intact (Figure 4) and is the "high ground" at the site. Remnants of the roads leading to the well pad still exists.

3.4.3 Vector Control

Since acquiring the property, DWR has worked cooperatively with the Solano County Mosquito Abatement District (SCMAD) to control mosquitoes. SCMAD annually samples properties in Suisun Marsh for mosquito production. Prior to DWR acquiring the parcel, SCMAD had records of only two treatments at the site: October 1998 and October 2000. Solano County Mosquito Abatement District inspected the site in October 2004 and found excessive mosquito production, primarily in the areas dominated by salt grass. SCMAD aerially sprayed the parcel in October 2004 and subsequently billed DWR for vector control. No treatment was necessary in 2005 or 2006.

3.4.4 Non-native vegetation

While much of the vegetation on site is native, desirable marsh species, several acres of *Phragmites australis* are present in the ponds. This species is a rapidly spreading weed that out competes native emergent vegetation. It is a problem throughout Suisun Marsh, and marshwide eradication/control programs have been initiated. An invasive species monitoring and control program is discussed in section 6.2.12.

3.4.5 Public Access

Public access has been restricted within the project area as vehicular access to the site requires driving through private property. DWR has an easement to access the site for scientific or management purposes, but this easement is not for public access. Limiting public access from the adjacent waterways is more difficult to enforce since the site is open to tidal action. Several 'No Trespassing' signs have been installed along the exterior levee and at the breach locations to discourage the public from accessing the site by boat. In addition, the DFG warden has been patrolling the site when practical. DWR will continue to discourage public access due to liability concerns and for the protection of sensitive species.

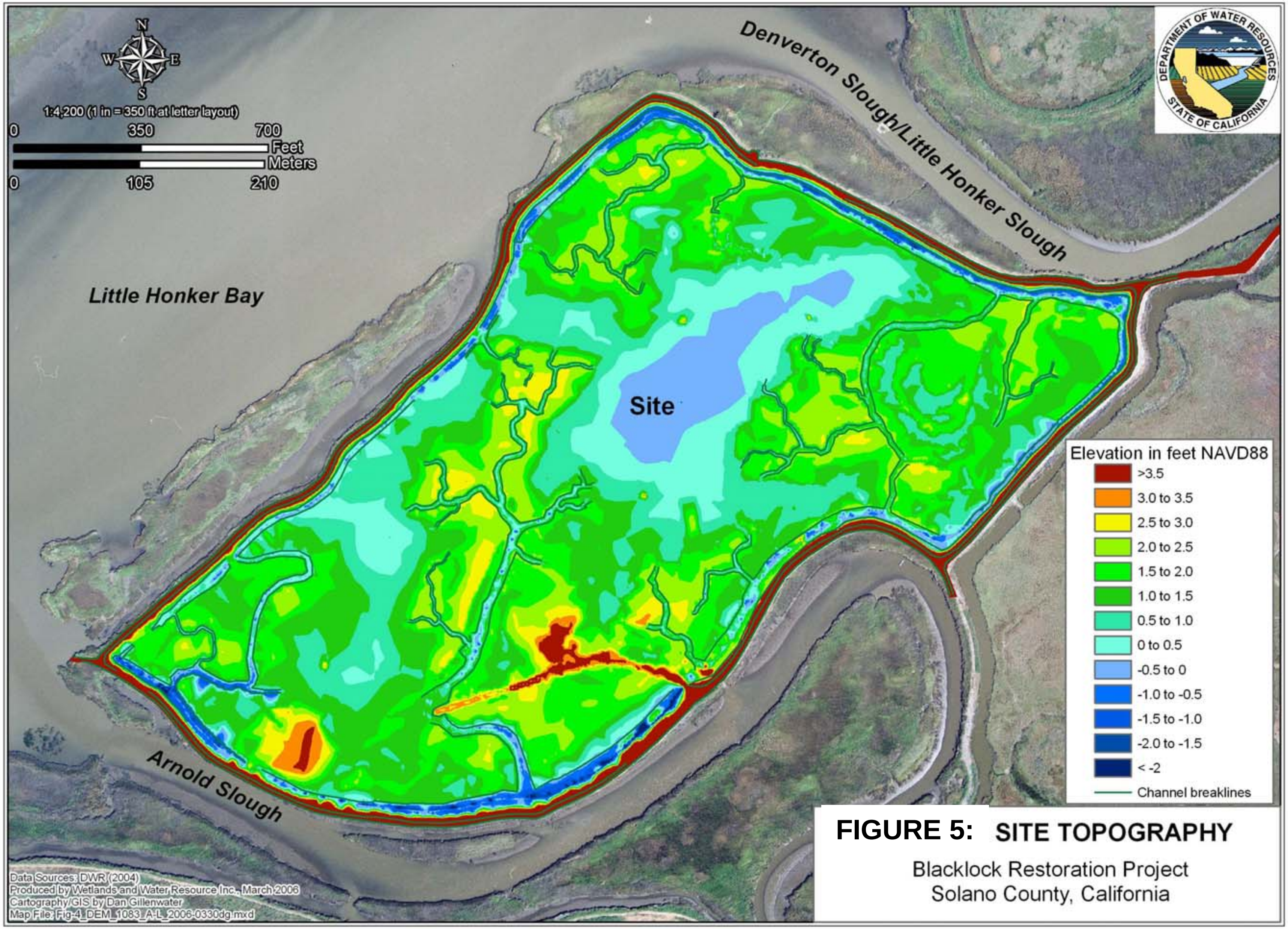


FIGURE 5: SITE TOPOGRAPHY

Blacklock Restoration Project
Solano County, California

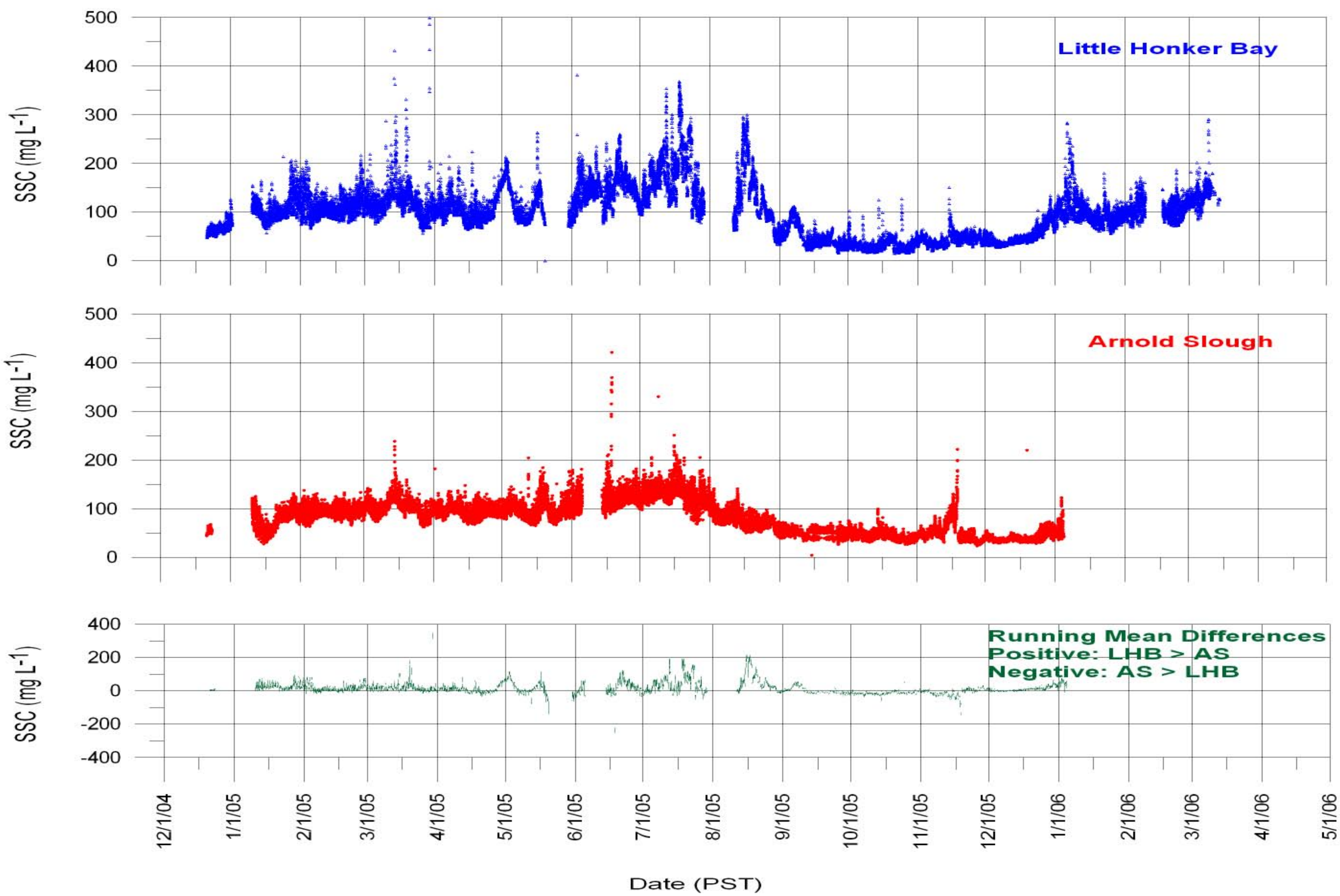


FIGURE 6: SUSPENDED SEDIMENT CONCENTRATIONS AND COMPARISONS

Blacklock Restoration Project
Solano County, California

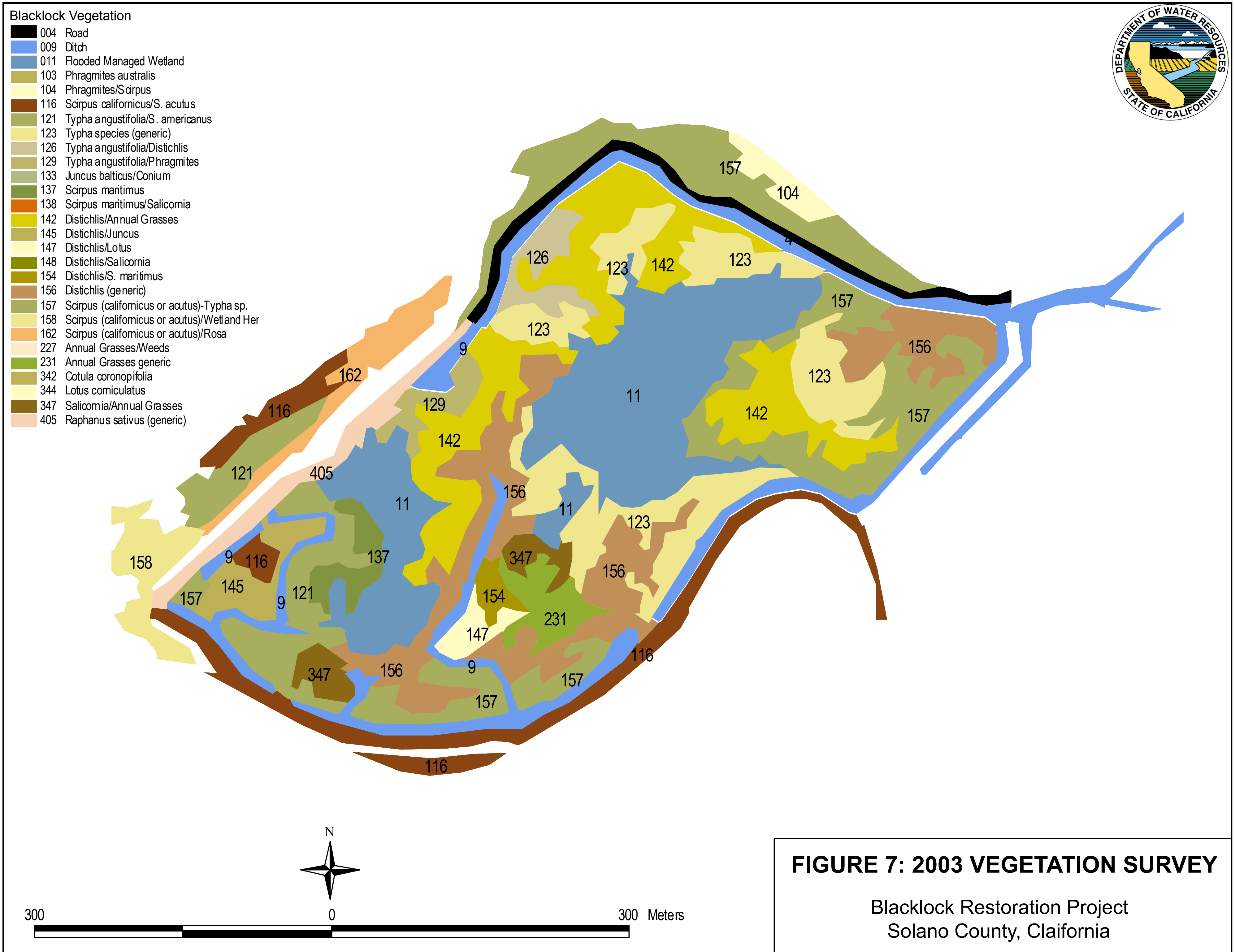


FIGURE 7: 2003 VEGETATION SURVEY

Blacklock Restoration Project
Solano County, California

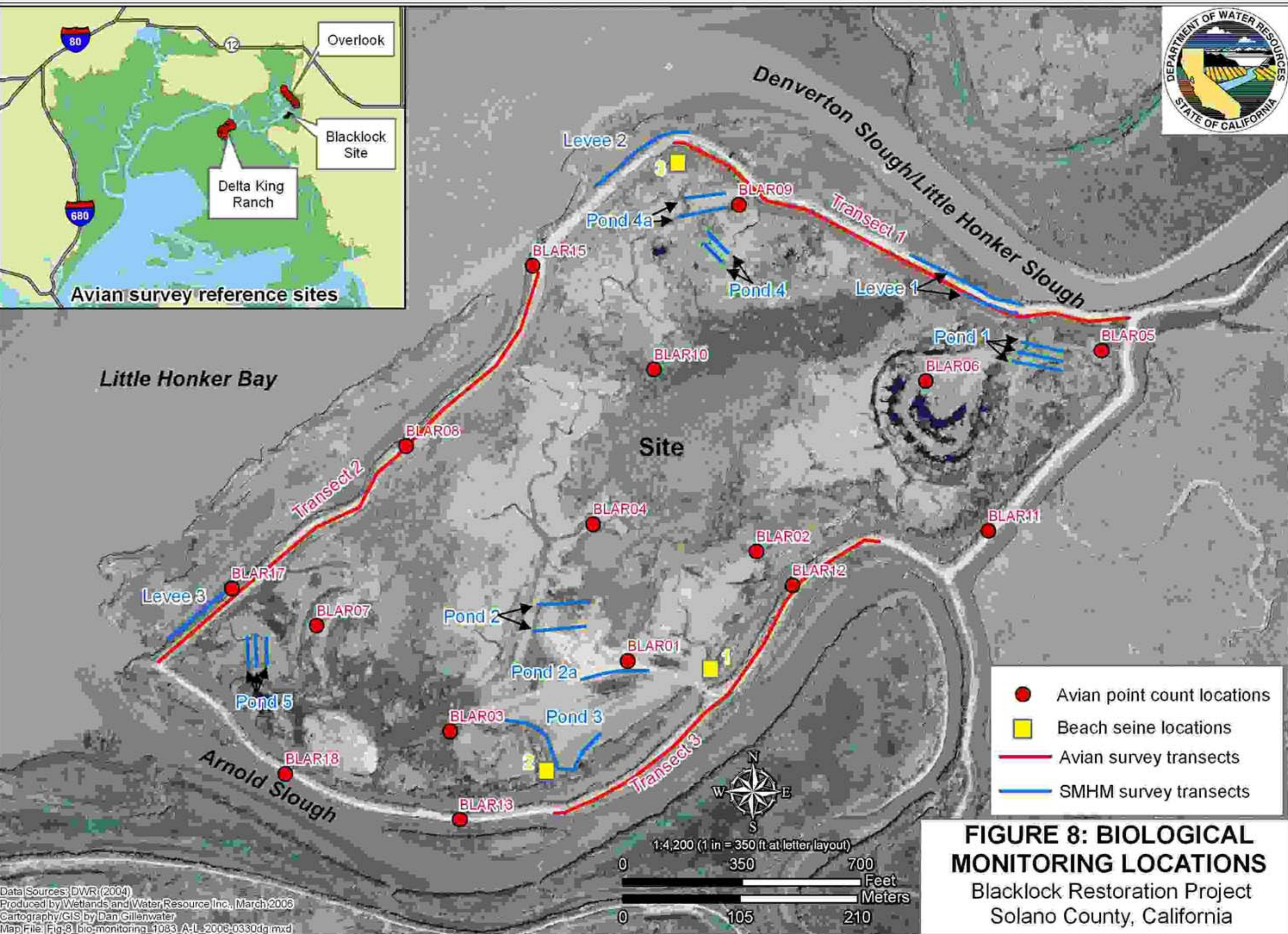


FIGURE 8: BIOLOGICAL MONITORING LOCATIONS
Blacklock Restoration Project
Solano County, California

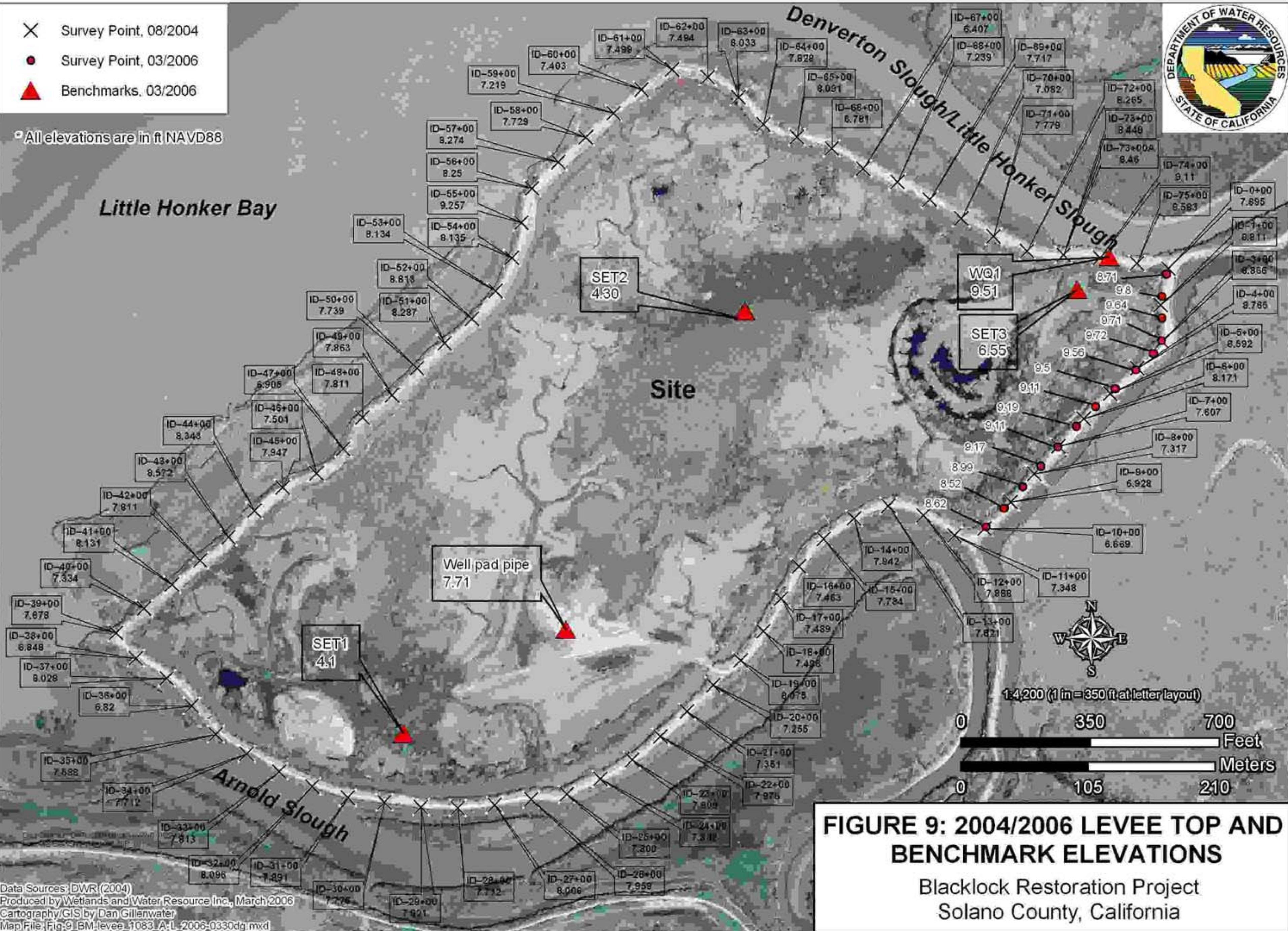


FIGURE 9: 2004/2006 LEVEE TOP AND BENCHMARK ELEVATIONS

Blacklock Restoration Project
Solano County, California

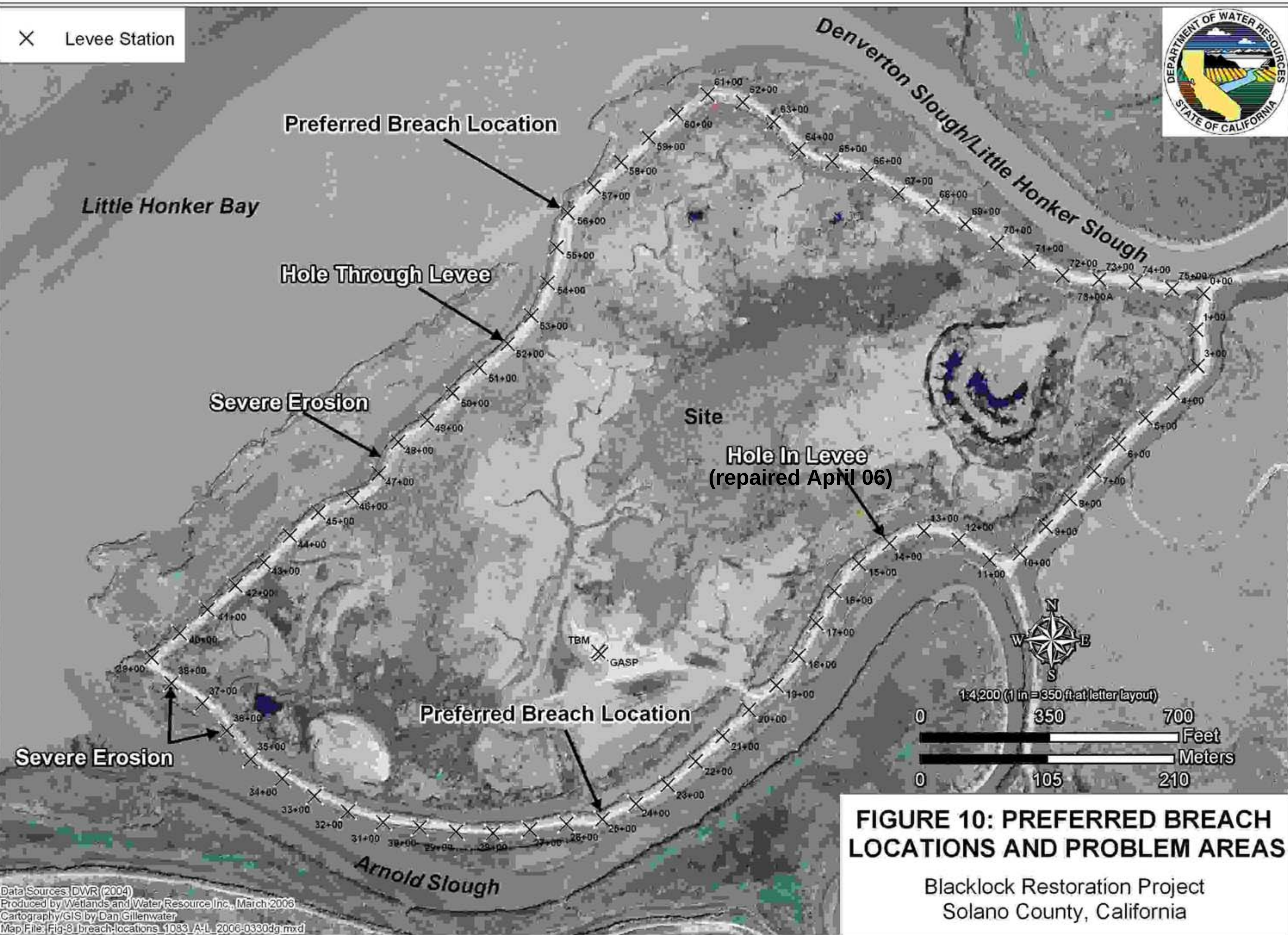


FIGURE 10: PREFERRED BREACH LOCATIONS AND PROBLEM AREAS

Blacklock Restoration Project
Solano County, California

FIGURE 11 – Brush boxes and revegetation on cross levee

4.0 IDENTIFYING OPTIONS FOR LEVEE BREACHES

This section describes the evaluation of levee breach scenarios for project planning purposes and proposes preferred locations for constructed levee breaches. This section also describes the details of hydrodynamic modeling conducted prior to project implementation, in support of restoration planning for the site.

4.1 Identifying Options

To achieve project goals and objectives of restoring the Blacklock property to a self-sustaining functioning brackish tidal marsh, candidate breach locations were evaluated to optimize import and deposition of adjacent channel sediment to the site. The location of levee breaches has a significant influence on subsidence reversal through sediment accretion and vegetation development.

The effectiveness of a levee breach for importing sediment depends on several factors including orientation to prevailing wind, channel depth adjacent to the levee breach, topography of the area behind levee breach, remnant channel location, and vegetation composition.

- Orientation to prevailing wind. In general, the breaches oriented to receive prevailing wind fetch are more likely to receive suspended sediment on flood tides, especially during fair wind afternoon periods.
- Adjacent channel sediment availability. The availability of suspended sediment in adjacent channels is partly a function of channel depth. Breaches near shallow channels or shoals may import higher suspended sediment concentrations.
- Site topography behind levee breach. An important element of promoting suspended sediment influx into a restored site is the ability to transport sediment throughout the site. Breaches should be located adjacent to low points within the site interior so as to facilitate tidal transport of suspended sediment throughout the site.
- Remnant tidal sloughs. To the extent possible breaches should be located to take advantage of remnant tidal creek channels to conduct tidal energy further into the site and to re-establish those channels as natural channels to the extent possible.
- Vegetation composition. Similar to the topography immediately behind the levee breach, vegetation composition will also control tidal energy penetration. Tidal energy will enter the restoration site as a “jet” with significant shear flow to either side of the maximum velocity zone. It is desirable to locate levee breaches such that the high velocity zone is relatively unobstructed by vegetation.

4.2 Hydrodynamic Modeling to Evaluate Options

DWR staff utilized hydrodynamic modeling as a planning and predictive tool to investigate alternative breach options for the Blacklock Restoration Project. RMA2, a depth-averaged two-dimensional hydrodynamic model (King, 1997), was used to simulate the water levels on the Blacklock property and its vicinity. Using a turbulence sub-model to represent the local effect of velocity gradients, RMA2 applies the finite element method to solve the equations of mass and momentum conservation, thus describing the depth-averaged two-dimensional unsteady hydrodynamics within the water body. The model has the capability to simulate irregular boundaries, dry and wet node conditions and sub-surface flows on tidal wetlands.

The RMA model is based on the equations of mass and momentum conservation (Navier-stokes equations). Since these equations are deterministic, error margin is not of a concern (unlike statistical formulations). Navier-stokes equations are able to describe a flow field very accurately given boundary conditions. In contrast, there are several sources of uncertainty that are likely greater than any error in the model formulation. These include uncertainty about friction due to variable vegetation, and general uncertainty about the location and nature of natural levee breaches as they made it appear at the site. The model is used to highlight the sensitivity of the flow field inside Blacklock to these very frictional and geometric uncertainties. The Bay Delta RMA2 model was provided by Resource Management Associates Inc through a contract with DWR.

4.1.2.1 Modeling Scenarios

Several breach scenarios were modeled. Scenarios evaluated effects of varying locations, widths, and numbers of breaches. The first set of scenarios investigated the impact of breach size on Blacklock water levels. Two conditions were considered: the first adds a 10 meter levee breach at stn. 55+00 (Scenario 1) (Figure 10), the second adds a levee breach at the same location but increases the breach width from 10 meters to 20 meters (Scenario 2). Both scenarios have the breach footing elevation at -0.34 meters NAVD. The second set of scenarios investigated the impact of breach locations. The breach was made at stn. 47+00 (Scenario 3) and stn. 55+00 (Scenario 4), respectively. Both scenarios have a breach width of 20 meters and the breach footing elevation at -0.34 NAVD. A third set of scenarios investigated the impact of the number of breaches. Two conditions were assumed for this investigation, one with a breach at stn. 55+00 (Scenario 5) and the other with three breaches at stns. 36+00, 47+00 and 55+00 (Scenario 6). All the breaches have a width of 20 meters and a footing elevation at -0.34 meter NAVD. Finally, the sensitivity of the model, specifically the model's sensitivity to the bed roughness coefficient, was investigated. Three bed roughness coefficients (n = 0.07, 0.15 and 0.25) were considered for the sensitivity study. The levee breach condition was assumed to be the same as Scenario 1. The summary of scenarios is presented in Table 4. Modeling results are summarized below.

4.1.2.2 Modeling Results

<u>The Impact of breach size (Scenarios 1 and 2)</u>. Increasing the breach width from 10 meters to 20 meters did not significantly affect Blacklock water levels. Figures 12 and 13 show the water levels at node 4993 (east side of the property, bottom elevation 0.25 meter NAVD) and node 5457 (west side of the property, bottom elevation 0.045 NAVD) for the different levee breach configurations. Very little difference in the water levels can be seen between the two scenarios.

Table 4 - Summary of Modeling Scenarios

Group	Scenario	Breach Location	Breach Configuration	
			Width(m)	Footing Elevation (m NGVD)
Breach Sizes	1	Stn 56+00	10	-1.17
	2	Stn 56+00	20	-1.17
Breach Locations	3	Stn 47+00	20	-1.17
	4	Stn 56+00	20	-1.17
Breach Number	5	Stn 56+00	20	-1.17
	6	Stn 56+00 Stn 47+00 Stn 36+00	20	-1.17

The impact of breach location (Scenarios 3 and 4). Location of the breach significantly affected the low tide water levels. Figures 14 and 15 show water levels at nodes 4993 and 5457 for the breaches made at stns. 47+00 and 56+00. Stn. 47+00 is behind an island and is relatively hidden while stn. 56+00 has a direct connection to Little Honker Bay. Comparing the simulation results with the two breach locations, it is apparent that during low tides Blacklock water levels are lower if the breach was made at a location with a direct connection to the bay. The difference in the water levels between Scenarios 3 and 4 can be as high as 0.18 meter (7 inches) during a low tide. High tide water levels did not appear to differ significantly. This finding is significant for selecting a suitable breach location when water levels during low tides are of a main concern for certain species in the restoration process.

The impact of the number of breaches (Scenarios 5 and 6). The number of breaches also affected Blacklock water levels. Figures 16 and 17 show the water levels at nodes 4993 and 5457 for one breach and three breach conditions, respectively. Under a multiple (three) breaches condition, it was easier for water to be drained out of the property thus led to lower water levels during low tides. At node 4993, the difference in water level between the one-breach and three-breach conditions during low tide can be as high as 0.19 meter (7.6 inches). As with scenarios 3 and 4, high tide water levels were not significantly different.

Model Sensitivity. The model is sensitive to bed roughness coefficients (i.e., Manning's n). The higher the Manning's n, the higher the friction head loss, thus the lower the velocities and the higher the water levels. Figures 18 and 19 show the differences in water levels simulated with Manning's n equals 0.07, 0.15 and 0.25 in heavily vegetated areas. At node 5457, the difference in the water levels can be as high as 0.1 meter (3.8 inches) with n = 0.07 and n = 0.25 respectively.

Other simulation results. For Scenarios 1 through 6, during high tides, the water levels inside of the Blacklock property are the same as those on Little Honker Bay (Figures 20 and 21). However, during low tides, the water levels inside of the Blacklock property are always higher than those on Little Honker Bay. This may have resulted from the high friction loss caused by heavy vegetation on the property preventing water from draining during low tide.

It was also found that for Scenarios 1 through 6, the flow field on Blacklock is asymmetrical (Figures 22 and 23): it has longer ebb periods and lower velocities while the flood periods are shorter and velocities are higher. This asymmetry in flow field may provide a potential mechanism for sediment to be trapped in the Blacklock property and thus facilitate the marsh restoration processes if sediment supplies from the bay are high.

4.3 Additional Modeling Needs

Because sediment transport is important for tidal wetland restoration, DWR modeling staff recommends that future modeling include a sediment transport model for the Blacklock property and vicinity to study sediment transportation and deposition. In addition, DWR modeling staff recommend future modeling include a water quality model for the Blacklock property to evaluate possible water quality issues involved in the restoration process.
The hydrodynamic, sediment and water quality models would need to be calibrated and verified when the stage, flow, sediment and water quality data at the Blacklock property are available.

4.4 Proposed Alternative - Constructed Levee Breaches

Modeling results indicate that the site drains better at low tide with two breaches on the property. Therefore, two locations, stns. 55+00 and 25+00 were identified as preferred breach locations for the constructed breach alternative. Stn. 55+00, along Little Honker Bay (Figure 10) would allow for an unimpeded exchange of flows during tidal cycles. Because there is no in-channel island or fringing tidal marsh here, it is expected that a breach at this location would optimize the transport of available Little Honker Bay sediments into the property to raise surface elevation through sediment deposition. In addition, a breach at this location could take advantage of the remnant tidal slough network within the property. It is unlikely that an unintended levee failure would occur at this location. The levee is wider and higher than other areas and there is riprap on the waterside slope and toe.

The second breach would be located along Arnold Slough, preferably at stn. 25+00, which lines up with an existing channel and would serve the southwest corner. An alternate location for the second breach is near stn. 35+00, which is close to an existing channel but avoids the outboard marsh (a viable alternative to stn. 25+00). In addition, the levee is highly eroded at the southwest corner of the property. One consideration in determining preferred breach location is that when the tide enters through a breach, it's most likely to continue in a straight line for some reasonable distance before meandering; just south ("right") of the stn. 55+00 breach, once past the borrow ditch, is higher ground, which could have the effect of limiting tidal exchange to the southwest corner. Thus a breach between stns. 20+00 and 35+00 would serve the southwest corner well.

Modeling suggests that a breach size of 65 feet (20 meters) would be sufficient for full tidal exchange.

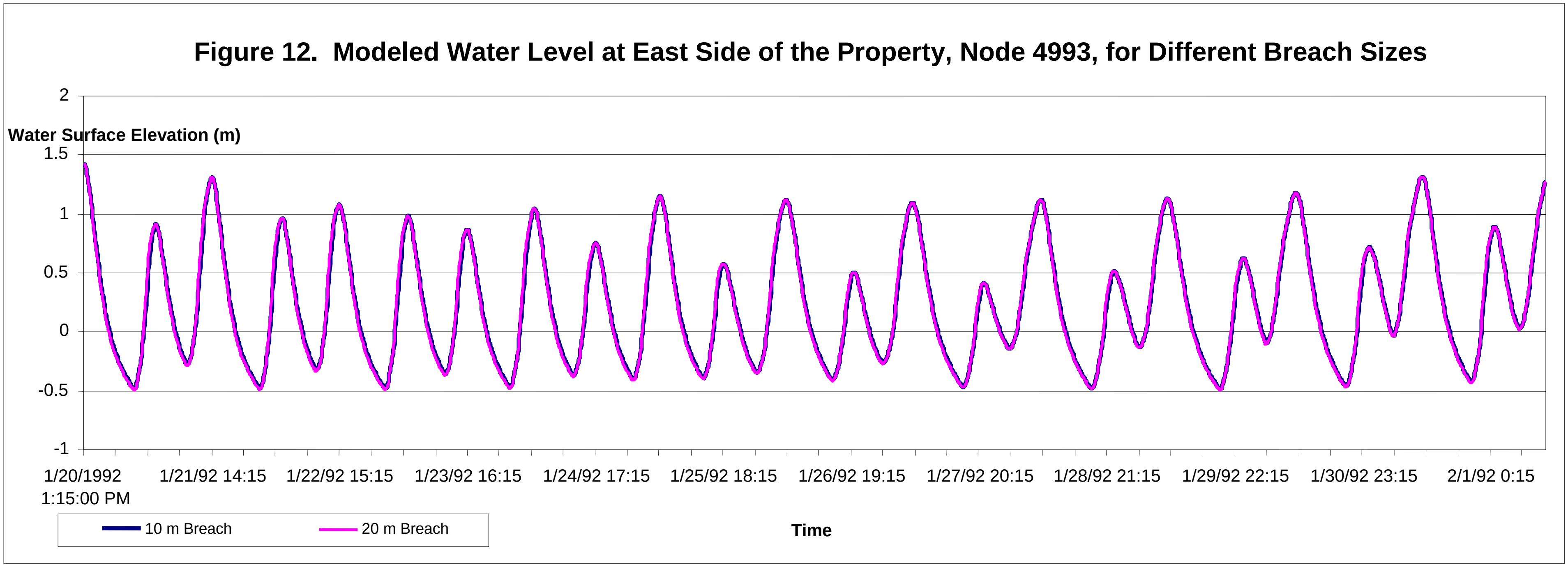


Figure 12. Modeled Water Level at East Side of the Property, Node 4993, for Different Breach Sizes
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
10 m Breach
20 m Breach
Time

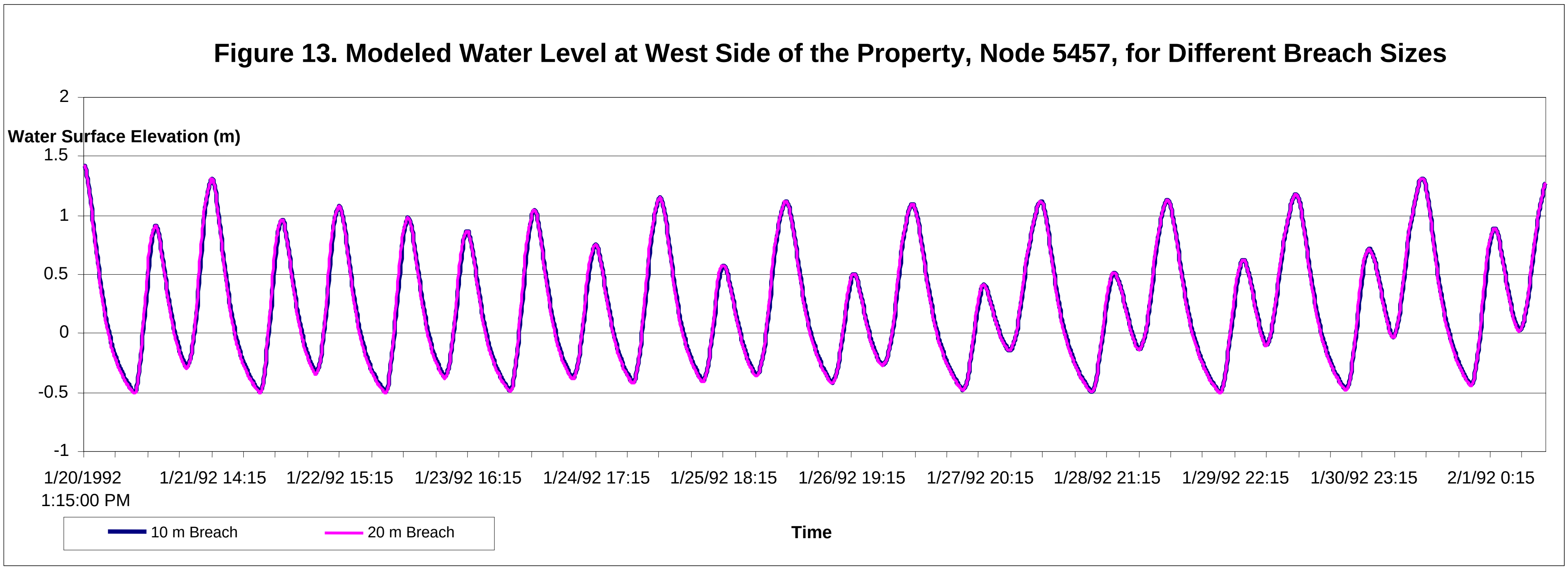


Figure 13. Modeled Water Level at West Side of the Property, Node 5457, for Different Breach Sizes
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
10 m Breach
20 m Breach
Time

Figure 14. Modeled Water Level at East Side of the Property, Node 4993, for Different Breach Locations

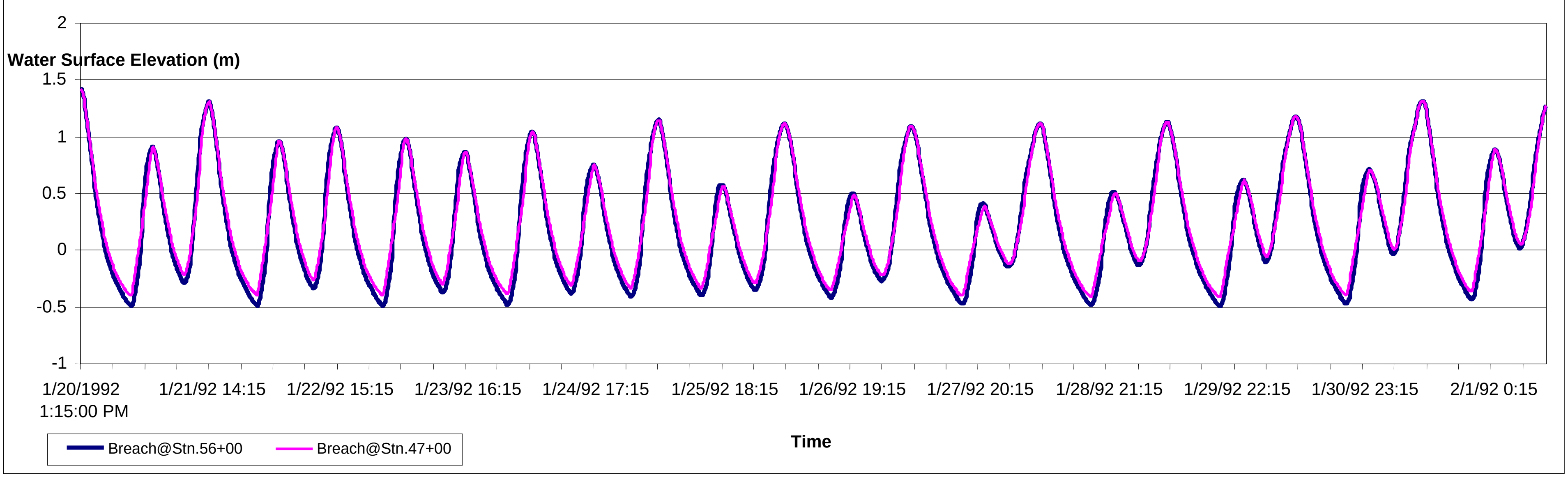


Figure 15. Modeled Water Level at West Side of the Property, Node 5457, for Different Breach Locations

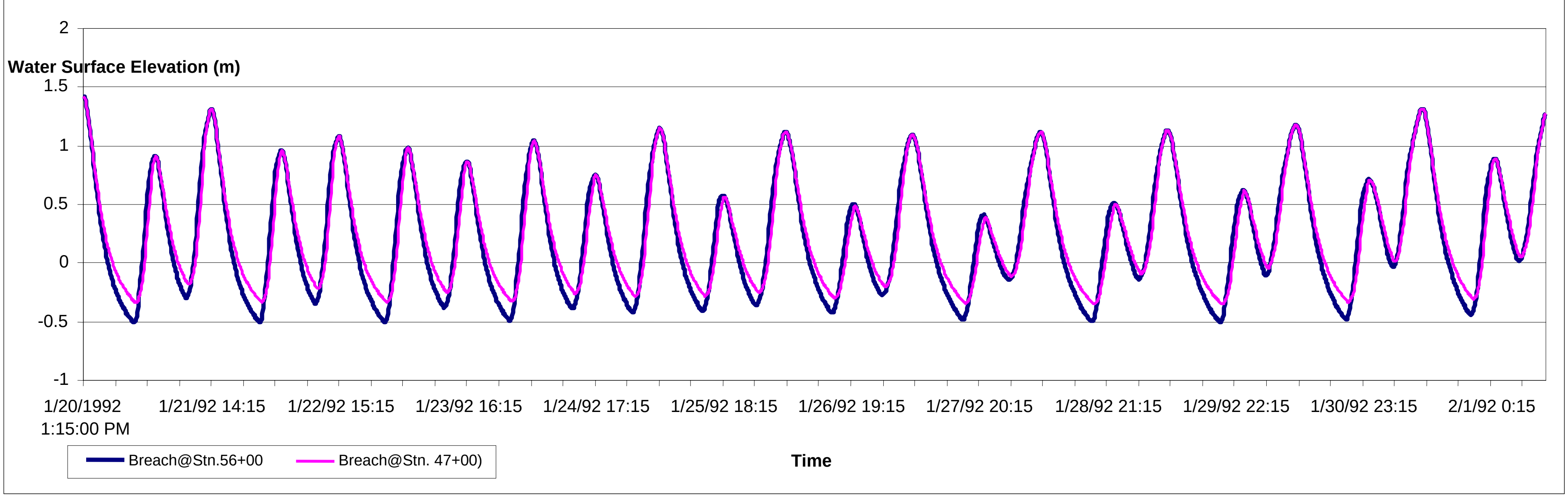


Figure 16. Modeled Water Level at East Side of the Property, Node 4993, for Different Number of Breaches

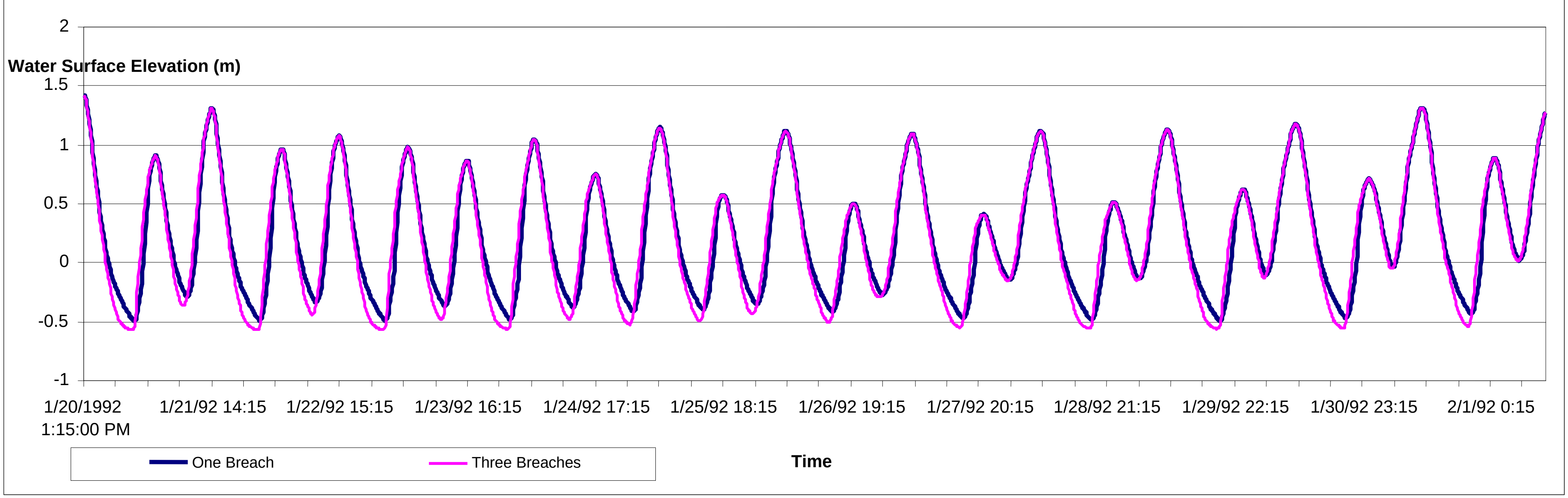


Figure 17. Modeled Water Level at West Side of the Property, Node 5457, for Different Number of Breaches

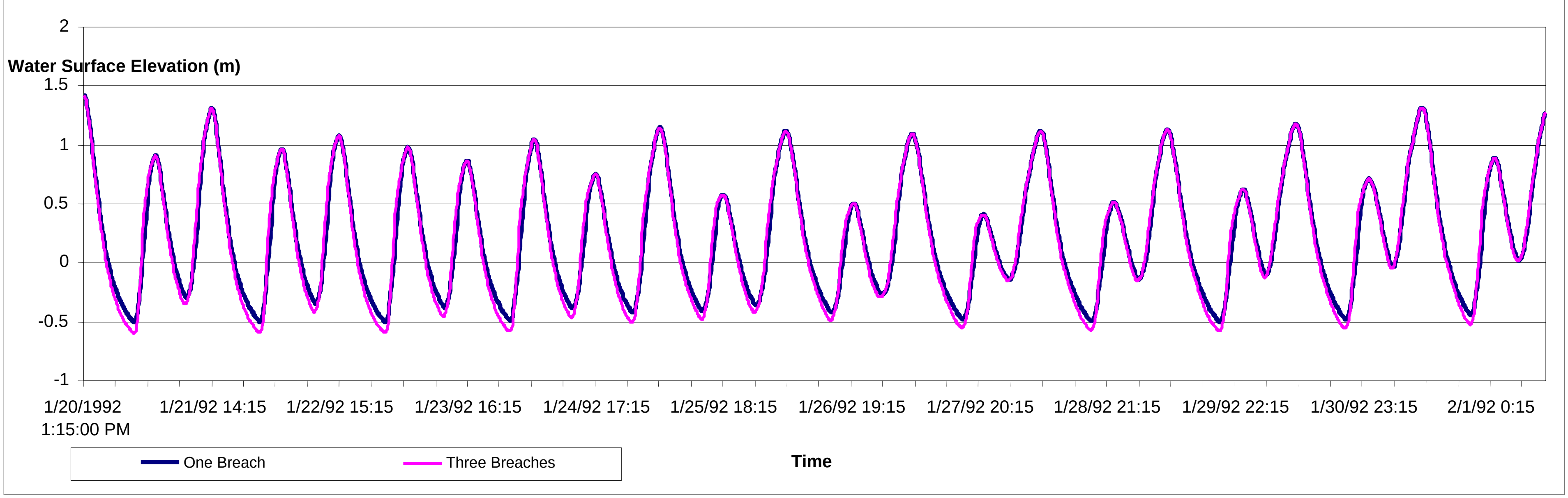


Figure 18. Modeled Water Level at East Side of the Property, Node 4993, for Different Manning's n

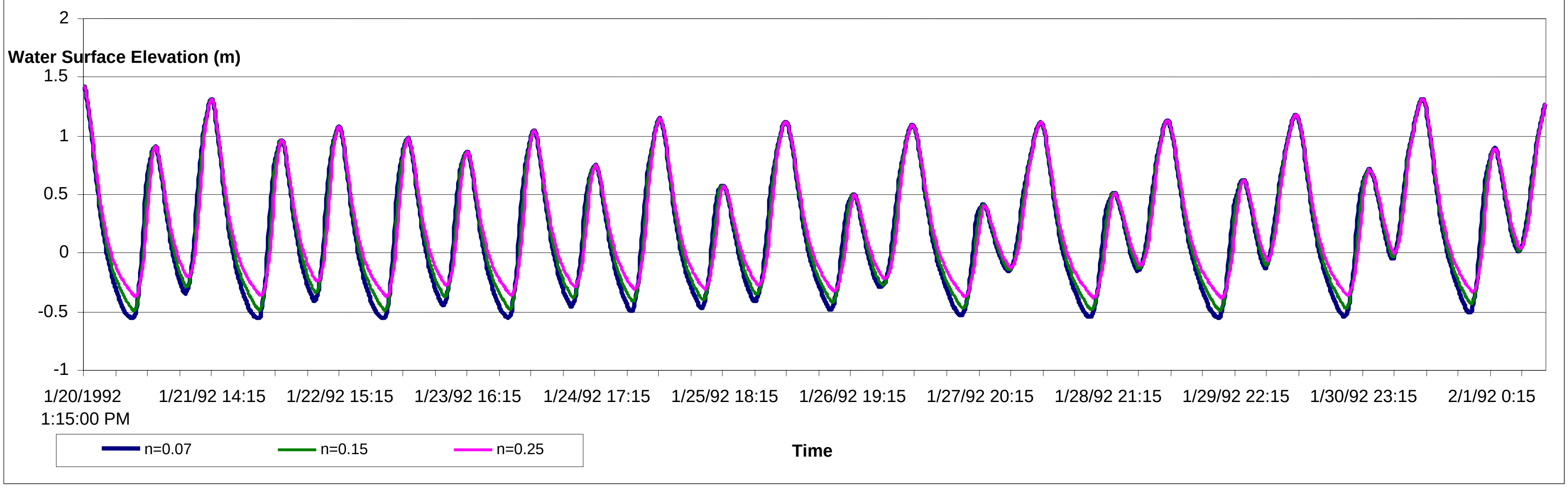


Figure 19. Modeled Water Level at West Side of the Property, Node 5457, for Different Manning's n

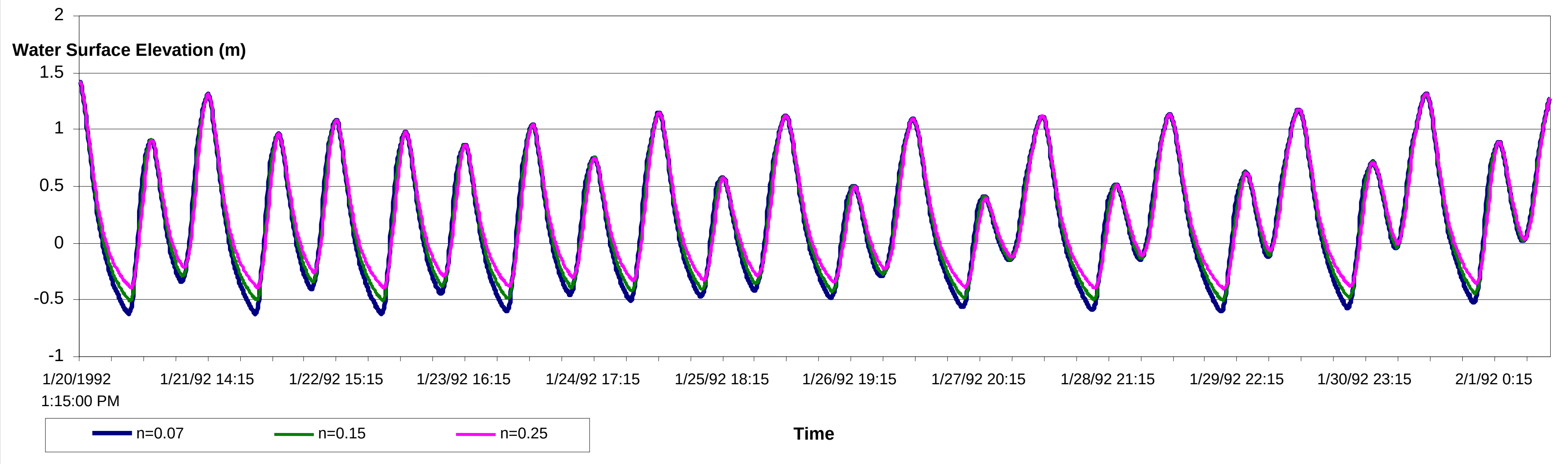


Figure 20. Modeled Comparison of Blacklock and Little Honker Bay Water Levels (One Breach)

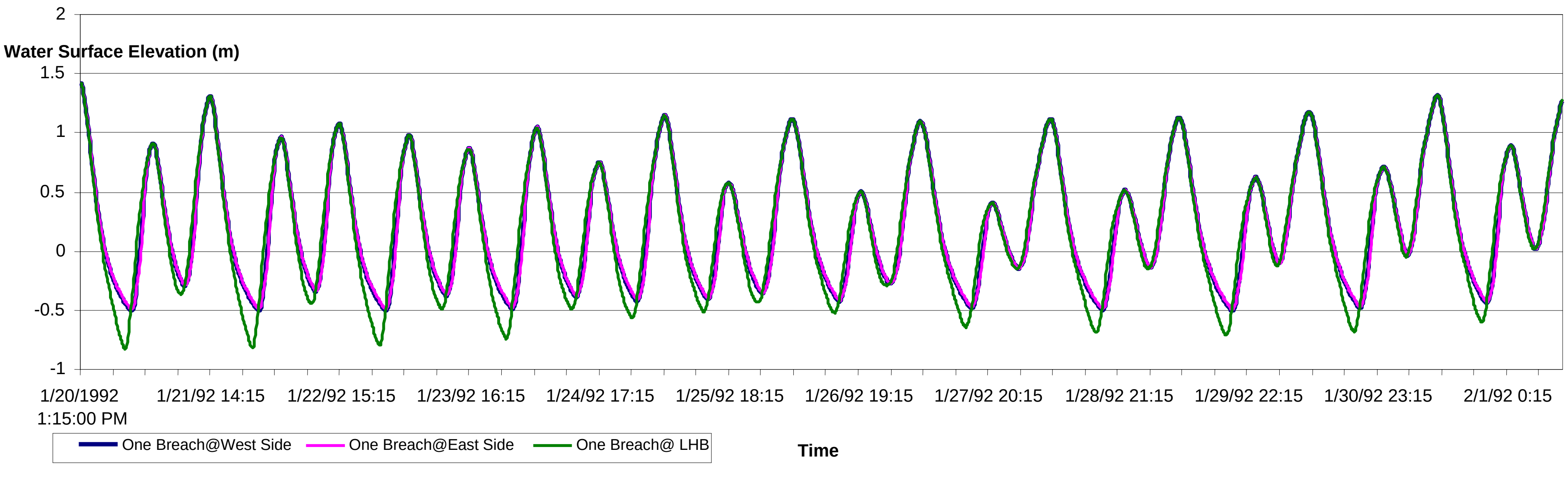
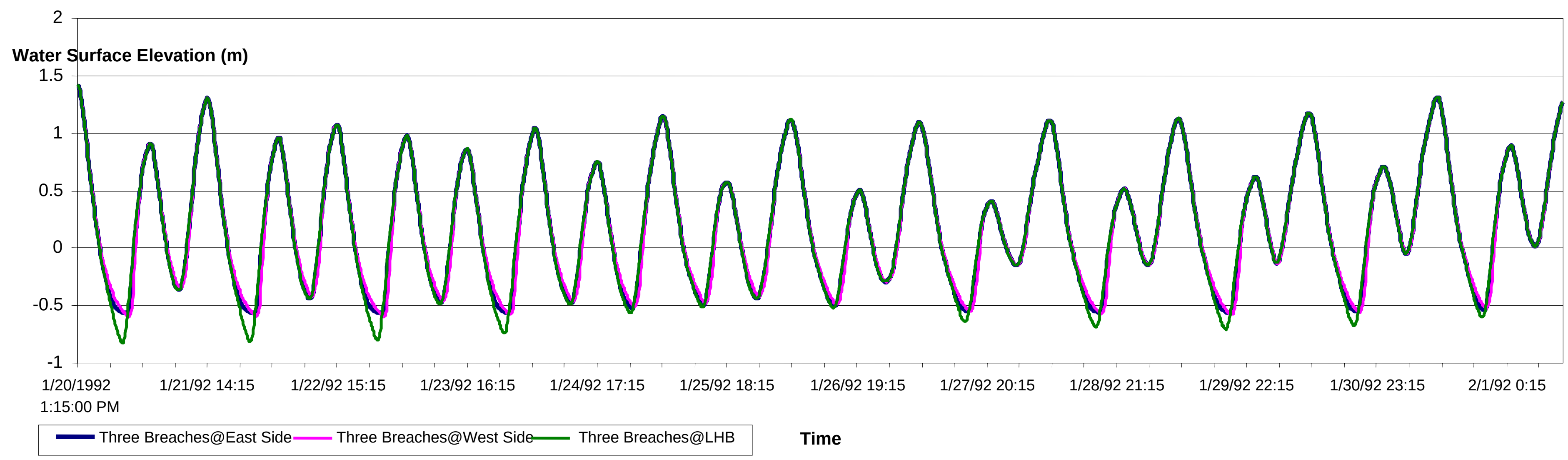


Figure 21. Modeled Comparison of Blacklock and Little Honker Bay Water Levels (Three Breaches)



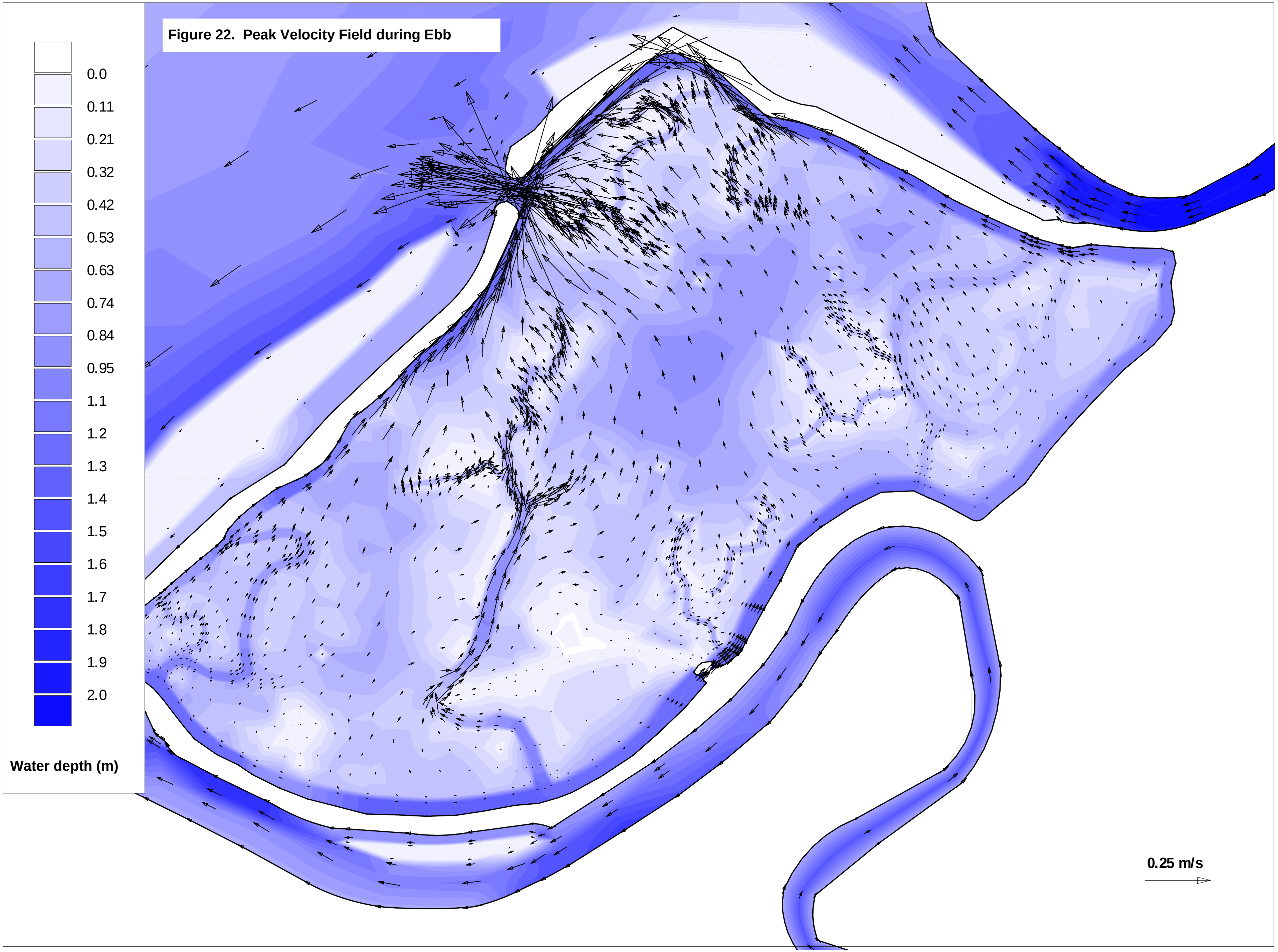


Figure 22. Peak Velocity Field during Ebb
0.0
0.11
0.21
0.32
0.42
0.53
0.63
0.74
0.84
0.95
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Water depth (m)
0.25 m/s

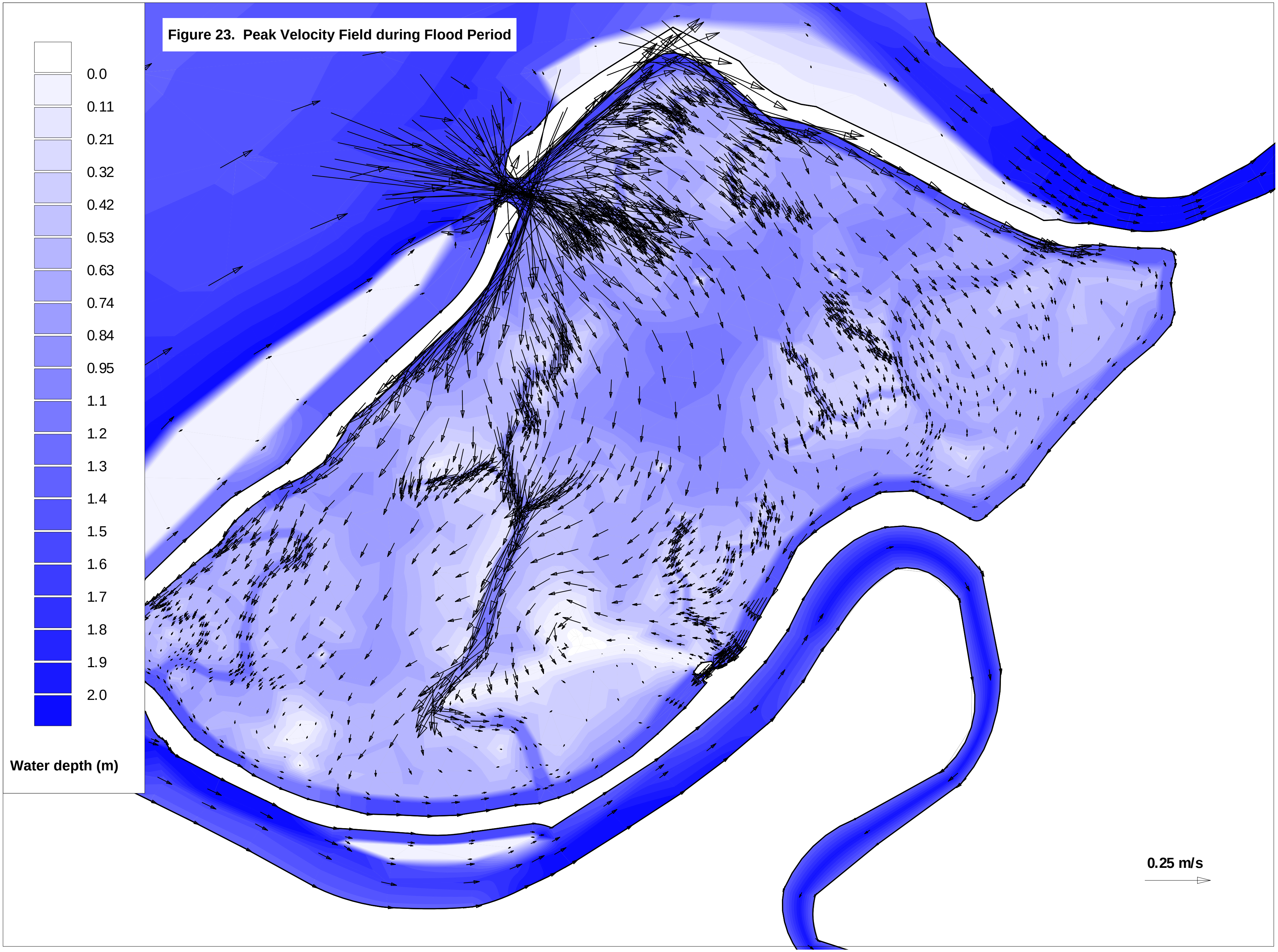


Figure 23. Peak Velocity Field during Flood Period

5.0 FINAL DESIGN AND IMPLEMENTATION ACTIVITES

This section describes the actual implementation of the Blacklock Restoration project to date and potential future adaptive management actions.

The underlying restoration requirement for this site is subsidence reversal, as the site ranges from 3 to more than 5 feet below local MHW (Figure 4). Tidal datum for the area is shown in Table 1. The overall approach for the Blacklock Restoration Project calls for a passive strategy in which the exterior levee is breached, natural sedimentation and plant detritus accumulation restores intertidal elevations, and natural colonization establishes the plant and wildlife communities. The project included a “pre-vegetation” element to promote these natural restoration processes. This occurred during the interim management stage as described in section 2.4. Tidal flow is expected to utilize the existing remnant channels to some extent, with some new channels forming as sedimentation progresses. This design is a minimal-engineering approach that relies on natural processes to meet project goals and objectives.

5.1 Constructed Levee Breaches

A breach was constructed at the preferred location along Little Honker Bay (stn 55+00) on October 3rd and 4th 2006 (Figure 2). This was one of the preferred locations identified by hydrodynamic modeling and described in the Draft Restoration Plan (April 2006). Because there is no in-channel island or fringing tidal marsh here, this breach will allow for an unimpeded exchange of flows during tidal cycles and would optimize the transport of available Little Honker Bay sediments into the property to raise surface elevation through sediment deposition. This breach is 61 feet wide at the levee crown and was excavated to a depth of approximately -3 feet NAVD (Figure 24)

A breach was not constructed at the second proposed breach location along Arnold Slough in October. This decision was made because the levee in the vicinity of the second breach is severely eroded and expected to fail soon. However, construction of a second breach was identified in the permits authorizing construction, and can be constructed at a later date, under adaptive management, if it is determined necessary to meet project objectives.

5.2 Unintended Levee Failure

In addition to the constructed breach at stn. 55+00, there is a second smaller breach near stn 52+00. This natural levee failure occurred in mid-July 2006, beginning as a hole through the levee. The initial failure of the levee created muted tidal conditions, as the breach was not very deep through the levee section. Over the next few months the breach eroded in depth and width and appears to have stabilized at approximately -1.5 feet deep and 40 feet wide at the levee crown (Figure 25). While this natural breach increases the tidal flow into the site, it is expected that less Little Honker Bay sediment is transported through this breach because the in-channel island at this location. Also, this breach is not as deep, which limits the tidal flow out of the site during the ebb tides. Breach geometry will be monitored perodically, although access issues impacts the ability to enlarge or deepen the breach under adaptive management.

5.3 Construction Methods

Construction activities occurred on October 3 and 4 2006. On October 3, the excavator was mobilized at the site and material was removed from the side slopes. On the morning of October 4, the contractor continued to remove material from the levee section during low tide. The breach occurred at approximately 10:50 am. Breaching coincided with the rising tide, allowing the remaining levee material to flow into the property instead of out into Little Honker Bay. The contractor continued to remove material, widening and deepening the breach to the design specifications.

A long reach excavator was used to construct the levee breach. All work was done from the levee crown and the excavator accessed the site from the levee. Access for heavy equipment was from Shiloh Road, through the Blacklock Ranch (ownership 604), and to the site.

All permit conditions and construction best management practices (BMPs) outlined in the environmental documentation and permits were followed to minimize impacts to the project area and sensitive habitats. A qualified biologist was on site at all times during construction.

The majority of the excavated material was placed in the borrow ditch adjacent to the levee breach (Figure 26) to a depth of not more than <1 ft NAVD (MLLW). A small amount of the excavated material was placed on the levee slope and crown adjacent to the breach to provide safe working conditions for the excavator.

5.4 Operations and Maintenance

5.4.1 Cross Levee Maintenance

As described in section 3.4.1, the cross levee was converted to exterior levee specifications during 2004 and 2005. Brush boxes were installed, and the levee was revegetated to provide wavewash erosion protection. The brushboxes (Figure 11) are expected to provide erosion protection for 3-5 years, giving time for the revegetated levee to mature. This alternative approach to protect the levee slope will be evaluated for effectiveness. If the brushboxes do not provide adequate protection, additional measures will be considered.

The east (non-project) side of the levee sustained moderate damage during the January 2006 storm and high tide event. The adjacent property flooded during the high tides and wind fetch across the open water of the adjacent parcel resulted in erosion to the east side of the cross levee. This side of the levee may be repaired and revegetated, pending the acquisition of permits and materials. Maintaining the cross levee is, and will continue to be, a high priority.

5.4.2 Exterior Levee Maintenance

Now that the levee is breached and the property is under tidal influence, maintenance to the exterior levee will be minimal. The exterior levee on the eastern side of the property will be maintained on an as needed basis to ensure the integrity of the cross levee. In addition, the exterior levee will be maintained from stn.11+00 to stn 25+00 until a determination is made that unimpeded tidal exchange is achieved and that a second constructed breach will no longer be considered an option. Maintaining this section will allow access for an excavator if it is determined that an additional breach on this side of the property is needed. In addition, maintaining this section of levee will allow access to the interior of the site for data collection and small boat access at low tide.

Vegetation control including mowing and weed control will continue along the crown of the exterior levee to allow pedestrian access for as long as is practical. This will allow agency staff and those involved with the restoration access to evaluate levee and site conditions, and to conduct monitoring. Except for driving across the cross levee and to where the well pad road intersects the exterior levee, access will be limited to foot traffic and ATV’s since the levee is unsafe for larger vehicles.

It is expected that the remaining exterior levees will erode over time, resulting in additional breaches.

5.4.3 Vector Control

SCMAD has developed policies and BMP's for management of tidal marsh restoration and these BMP's will be followed to control mosquito production on restored wetlands at Blacklock. After tidal inundation, DWR anticipates that active control will not be necessary since the salt grass areas are inundated, but will continue to work cooperatively with SCMAD as needed, to minimize mosquito production at the site.

5.4.4 Invasive Species Control

Exotic plants and animals often thrive under conditions at wetland restoration sites (Zedler, 2000). A program for the control of non-native invasive plant species has been developed as part of the vegetation monitoring plan for this project (see Section 6.2). Control of aquatic invasive species is likely to be difficult and will be best achieved by providing conditions more favorable to native species.

5.5 Adaptive Management

Adaptive management means taking informed, intentional actions designed to achieve pre-defined goals and objectives, observing the effects of those actions over a prescribed time period, evaluating the observed outcomes of those actions against a set of pre-defined criteria, and determining whether further actions should be taken based on those evaluations (Lee, 1993). In this adaptive management framework, it is critical to consider up-front what range of *feasible* actions could be taken, so that monitoring and decision making are focused on elements where intervention is possible and likely to have a measurable effect.

Adaptive management will be incorporated, as needed, to meet project goals and objectives. Physical and biological parameters will be monitored to evaluate success in meeting desired outcomes and to minimize undesirable outcomes. Physical parameters including tidal regime and breach geometry will be used as an indicator for future actions. Monitoring these physical parameters, in addition to using the computer model as a predictive tool, will inform project planners on specific actions that might be implemented. One important component of biological monitoring will be the use of this restoration site by native species. Adaptive management will be incorporated, as needed and practical, to meet the goal of providing suitable habitat for listed species.

The most obvious indicator for adaptive management actions is if the site is not meeting the restoration objective for full, unimpeded tidal flow. Under this scenario deepening or widening of the existing breach or constructing an additional breach may be necessary to achieve this objective. The site the will be monitored and observed for at least one year to allow time for the breaches to stabilize and natural evolution of the site.

The Adaptive Management Program for the Blacklock Restoration Project consists of the following elements:

- Milestone #1: At one year following the constructed breach, results of several monitoring parameters will be evaluated to determine whether any further actions are needed: the degree of tidal inundation, amount of sedimentation, breach geometry evolution, vegetation community changes, mosquito production, and invasive species colonization. These data will inform whether levee breaches need to be enlarged, new levee breaches added, or invasive vegetation control needed.

- Milestone #2: At two years following implementation of any changes following review at Milestone #1, results of the same parameters plus overall species use will be evaluated. These data will inform whether any final measures are warranted to alter the course of the site development to promote meeting its goals and objectives.

- Monitoring data review: In between and following these two milestones, monitoring data will be reviewed along with site observations made during monitoring, for early detection of desired or undesirable outcomes. If these reviews indicate clear adverse conditions prior to reaching either milestone, actions under those milestones would be moved forward as deemed appropriate by DWR and its Advisory Team.

5.6 NEPA/CEQA compliance

DWR, with cooperation with the SMPA ECAT agencies, prepared an Initial Study to evaluate and assess the environmental impacts of this project. DWR filed a Mitigated Negative Declaration with the Governors office of Planning and Research on July 13, 2006 and a Notice of Determination on August 14, 2006. USBR prepared an Environmental Assessment and prepared a Finding of No Significant Impact in September 2006. DWR is the CEQA lead for this project. USBR is the NEPA lead.

5.7 Environmental Permitting

Listed below are the regulatory requirements applicable to this project:

- San Francisco Bay Conservation and Development Commission
  BCDC issued permit No. M06-21(M) on September 22, 2006, authorizing construction of the levee breaches. In addition, BCDC approved the 10-year monitoring plan on September 26, 2006.

- Clean Water Act Section 404 Nationwide Permit 27 (US Army Corps of Engineers)
  The US Army Corps of Engineers issued a nationwide permit 27 (file number 30385N) on September 29, 2006 authorizing breach construction.

- Section 401 Water Quality Certification (RWQCB)
  The San Francisco Bay RWQCB issued a 401 water quality certification (file number 2128.03) on September 7, 2006 authorizing construction.

- Section 7 Endangered Species Act- Reclamation prepared a not likely to affect listed species determination under Section 7 of the ESA. The US FWS and NOAA –NMFS concurred with this determination in letters dated July 14, 2006 and August 9, 2006, respectively.

- California Endangered Species Act-informal consultation

A timeline highlighting project milestones for project implementation is presented in Table 5.

Table 5- Timeline for implementation

2001	CALFED ERP awards ECAT a grant for acquisition/restoration planning
December 2003	DWR acquired 70 acre parcel (Blacklock Ranch)
December 2003- September 2006	Interim Management of property –prepare for restoration
Summer 2004- January 2006	Raised and revegetated cross levee
2003-2006	Baseline monitoring (biological and physical)
2003-2006	Restoration Planning
April-06	Completed Draft Restoration Plan
May-06	Completed Review of Draft Restoration Plan (CDBA, Blacklock Advisory Team
June 2006	Submitted JARPA application (USACE, RWQCB, BCDC)
July	Completed CEQA compliance
September-06	Completed Detailed Monitoring Plan including cost estimates
August 2006	Endangered Species Consultation
September 2006	Completed Environmental Permitting and NEPA compliance
October 2006	Breached levee
October 2006	Began post-implementation restoration monitoring
June 2007	Completed Final Restoration Plan

5.8 Monitoring Plan

DWR, in coordination with the ECAT agencies, prepared a detailed monitoring plan. The Monitoring Plan was included as a condition of the BCDC permit authorizing construction. Details of the Monitoring Plan are presented in section 6.0 below. The plan includes detailed descriptions of post-implementation biological, chemical and physical conditions of the restored site. The estimated cost of implementing this plan is approximately $716,000.

5.9 Project Costs and Funding

DWR received a CALFED Ecosystem Restoration Program grant of $536,750 in 2001. The SMPA provided a cost share match using Suisun Marsh Mitigation Agreement Phase C funds.
The original proposal identified that Phase I (acquisition and pre-project monitoring) and Phase II (restoration plan development) would be completed with the available funds. It was anticipated that additional funding would be required to complete Phase III (environmental documentation and permitting), Phase IV (Implementation of the plan)

and Phase V (monitoring). However, the original grant funds, along with the matching cost-share dollars from the SMPA funded the project through implementation. Program costs, through March 2007 are presented in Table 6.

The existing monitoring program and current level of funding, was designed to meet the terms and conditions of the permits authorizing construction of the levee breach. DWR, in collaboration with the other ECAT agencies, has requested and is expecting to receive additional ERP funds through a Directed Action to implement the first three years of this monitoring program. The remaining years of the required 10 year monitoring program will be funded by the SMPA agencies. The SMPA agencies have agreed to provide $214,000 of SMPA Mitigation Agreement Phase C funds for data collection activities during years 4-10. Project management activities for years 4-10 will be funded by SMPA program funds (60 percent DWR, 40 percent USBR).

The agencies will continue to seek additional sources of funding (beyond SMPA) to implement additional monitoring of the site.

Table 6 - Project Costs as of March 2007

Project Management includes project management restoration planning, permitting; DWR and science advisor	**$150,500**
Acquisition includes purchase price, DLRW and acquisition survey	**$280,300**
Interim Management	**$35,000**
Operations and Maintenance includes exterior and cross levee repairs, maintenance, DLRW and surveys	**$185,500**
Data Collection includes biological and physical parameters, additional surveys, monitoring station. DWR and contractual	**$133,200**
Modeling	**$66,000**
Supplies and equipment	**$13,700**
Breach Construction/Implementation	**$16,000**
Total expended	**$880,200**

Figure 24 – Geometry of Constructed Breach

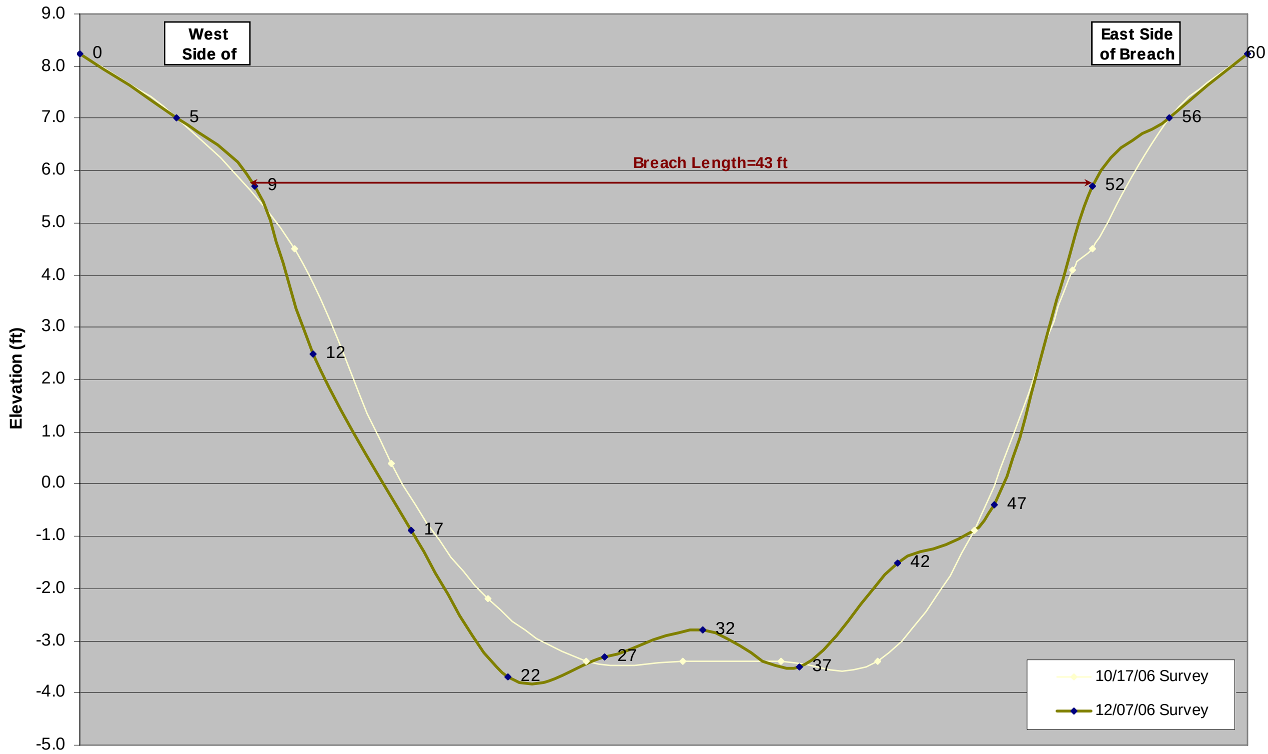


Figure 25 – Geometry of Natural Breach

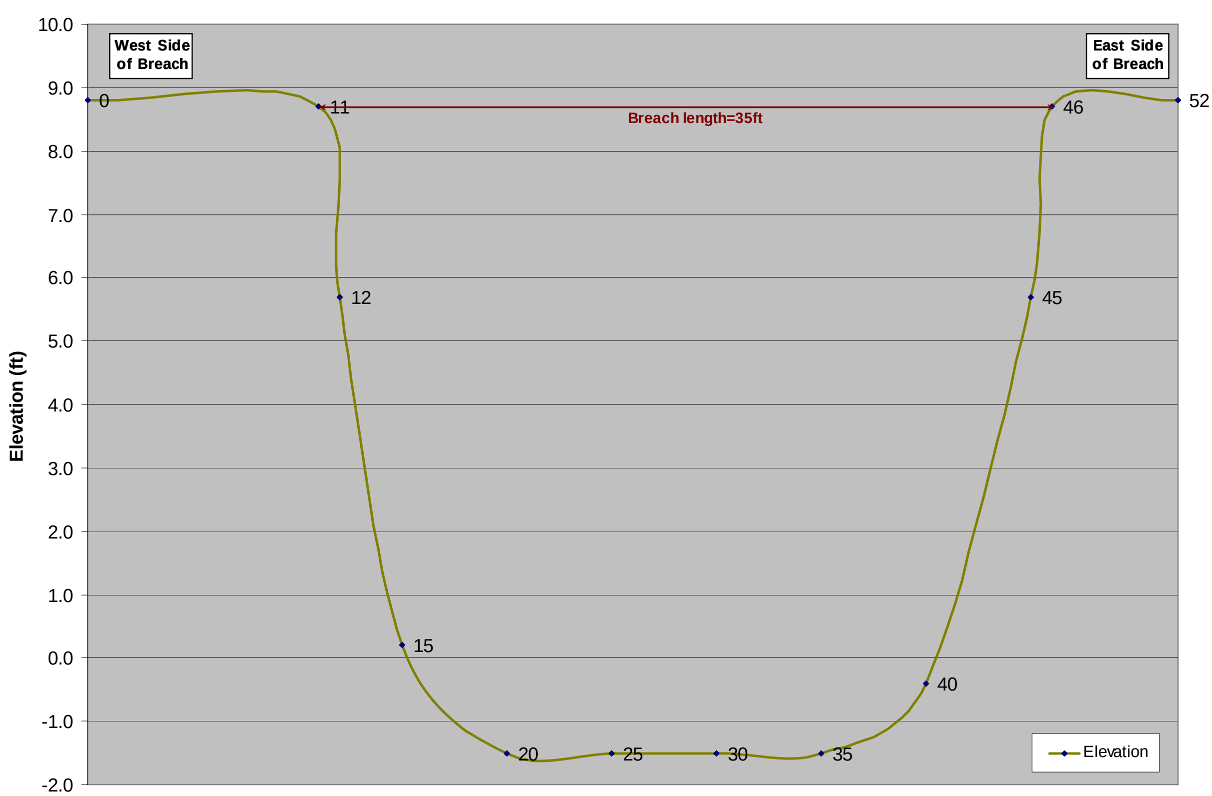
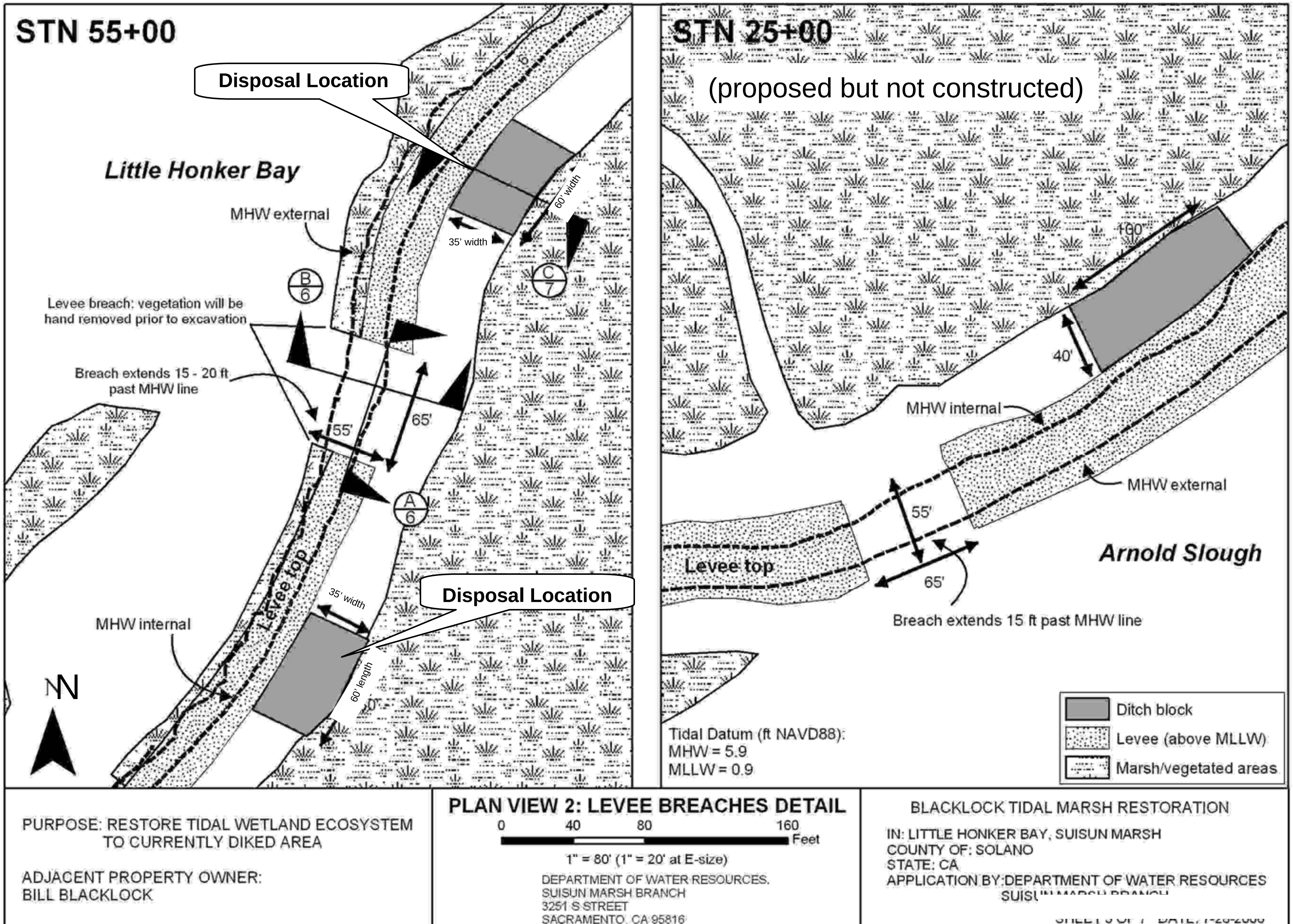


FIGURE 26 – Breach detail showing disposal location



6.0 MONITORING

This section describes the monitoring program prepared for the Blacklock Restoration Project. The goals identified for this project include: 1) restoration of the Blacklock parcel and 2) avoidance of adverse impacts from construction and restoration activities. This detailed monitoring plan was prepared as part of regulatory permitting for the project, and was specifically called for in BCDC permit M06-21 (M). Although restoration of this parcel to a fully functioning tidal wetland is expected to take several years, the required BCDC monitoring is for a 10 year monitoring period. Specific monitoring components are presented as a minimum monitoring approach to meet permit conditions described in BCDC permit M06-21 (M). Knowledge expected to be gained from this restoration includes but is not limited to, rates of sedimentation and marsh development, channel network formation and overall geomorphology, hydrology, water quality impacts, methyl mercury production, and species use at this location.

The Blacklock property was proposed, and will be included as part of the 2500 acres designated at “conservation” areas in Suisun Marsh, pending USFWS approval. SMHM monitoring at Blacklock will be conducted as part of the long-term SMHM monitoring program implemented on the conservation areas. Future monitoring at Blacklock will be consistent with any approved updates to the marshwide SMHM monitoring program.

Monitoring of this site will support multiple positive outcomes. First, it will document the expected beneficial effects of this project. Second, it will inform whether a third breach is needed for the southern part of the site. Third, it may inform design of the future tidal marsh restoration projects in Suisun, identifying effective approaches as well as potential impediments to successful future tidal marsh restoration projects as part of the Suisun Charter Implementation Plan. Finally, it may also help evaluate the suitability of future acquisitions for tidal marsh restoration. In this manner, Blacklock monitoring is a component of a larger effort aimed at providing protection and recovery of many species that benefit from tidal marsh in Suisun Marsh.

6.1 Restoration Performance Criteria

Restoration performance criteria were developed to evaluate the progress and effectiveness in meeting the goals and objectives of the project. The performance criteria for the Blacklock Restoration are:

- High tide heights inside the site will be substantially similar to those observed outside the site, within two years following a constructed breach.

- Low tide heights inside the site will be no more than 1 foot greater than those observed outside the site, within two years following a constructed breach.

- Restored marsh plain elevations will continually trend upwards until equilibrium is achieved.

- Native tidal marsh species will colonize and establish at the site. Native species shall be at least 50% of total vegetated areas. Species composition will be those species appropriate to the salinity regime and site elevations. It is expected that open water will remain on the site, possibly as much as 50% of total area.

6.2 Restoration Outcome Monitoring

Monitoring will both document the expected beneficial effects of this project and detect potential impediments to successful marsh restoration as well as potential adverse outcomes. Monitoring for each of the performance criteria will continue until performance criteria are satisfied. If performance criteria are not met, the causes will be investigated and adaptive management actions/corrective measures will be implemented. To the extent possible, elements of the monitoring program are consistent with regional monitoring programs currently in place in Suisun Marsh.

Monitoring components include:

- Inundation regime
- Levee breach geometry
- Sedimentation
- Channel network evolution
- Native marsh vegetation development
- Wildife
    - Avian surveys
    - SMHM surveys
- Fish surveys (pending additional secured funding)
- Water quality
- Methyl mercury
- Erosion of Adjacent Sloughs
- Control of Invasive Plant Species

The monitoring plan also includes an Adaptive Management component to ensure that the project goals and objectives are met. A schedule of restoration outcome monitoring is presented in Table 7.

6.2.1 Inundation Regime

Purpose: Evaluation of the tide stage data will inform DWR and the other SMPA ECAT agencies on whether the project is achieving unimpeded tidal exchange, which is a fundamental component of the restoration objectives, and whether a third levee breach is necessary in the southern part of the site to meet this objective.

Methods: Inundation regime will be evaluated by collecting the tide stage both inside and outside the property at 15-minute intervals. DWR maintains a water quality monitoring station (BLL) along Little Honker Bay/Little Honker Slough as part of the California Data Exchange Center (CDEC) monitoring network (Figure 4). This station measures precipitation, water temperature, wind speed and direction, atmospheric pressure and stage on an hourly basis. In early 2006. a pressure transducer was installed on the pond side of the levee to monitor tide stage within the site. Data is telemetered to CDEC so tide stage can be monitored remotely.

Modifications to the existing BLL station were made in May 2007 to facilitate the collection of water quality data within the restoration area. A walkway was installed over the borrow ditch and a new multi-parameter water quality monitoring probe (YSI 600 OMS with an ROX optical oxygen sensor was installed). The existing BLL site will be retrofitted with the same sensor to compare dissolved oxygen data in the slough with what is collected within the restoration site. A USACE nationwide permit #5 (scientific monitoring) and 401 water quality certification were obtained to authorize the retrofit of the existing monitoring station and install the probe. Currently, only stage and DO from within the restoration area are telemetered to CDEC. Additional equipment would need to be installed at the site to telemeter all of the parameters collected on the inside. The data is downloaded when the station is serviced (every two – four weeks) and stored in the Suisun Marsh database.

Comparing the tide stage inside the site with that of the slough will indicate whether the restoration is achieving unimpeded tidal flow. If tides are unimpeded, then the tide stage inside the site will be nearly identical to that which is measured in the adjacent slough. If tides are constricted, then the tide height inside the sit will be lower than outside; reduced height of high tides inside the site will provide a simple indicator of this problem. If low tides inside the site are higher than that of the adjacent slough, this indicates that the site does not drain effectively.

Tide stage in the restored area and in the adjacent Deverton Slough have been monitored since the constructed breach. As shown in Figure 27, tide stage tracks well, with the exception of the extreme low tides.

6.2.2 Levee Breach Geometry

Purpose: To track the evolution of this key design feature at the planned and naturally occurring breaches as an indicator of outcome and a possible diagnostic tool should inundation not be as anticipated especially in the southern part of the site.

Planned breaches were designed for unimpeded tidal flow at the time of construction. If breaches are constructed as designed, they may erode naturally in the early development stage then it may sediment in as the site's tidal prism decreases with overall sedimentation.

Evolution of a natural breach is dependent on the mechanism of the initial levee failure, the size and condition of the levee, and the levee material at the location of the natural breach. With an unintended levee failure, it will be imperative to evaluate breach geometry data closely in conjunction with tidal inundation data to assess if restoration goals are being achieved. If goals are not being achieved, adaptive management/corrective measures would likely include modifying the breach or breaching the levee in another location.

Methods: A post-breach survey will be conducted within one year after the constructed breach and will be compared to the cross-sectional survey conducted on October 17, 2007 (shortly after breach construction). A cross sectional survey of the natural breach at 52+00, and any additional unintended breaches will be conducted at the same time. The need and timing of additional cross sectional profiles of the will be dependent upon observed changes of the breach and an evaluation of tidal inundation (see task 3). Periodic cross sectional profiles may be conducted of the breach to document tidal scour or sedimentation and aid management decisions regarding breach maintenance.

Cross sectional profiles of any additional natural breaches (of significant size) will be conducted where appropriate.

Breach cross section and bathymetry data is collected from a 16-foot aluminum boat using a Trimble Pro-XR GPS/Beacon receiver with integrated GPS/MSK Beacon antenna utilizing a real time DGPS (differential GPS) receiver module and a fully automatic, dual-channel MSK beacon receiver module for receiving DGPS broadcasts conforming to IALA (International Association of Lighthouse Authorities) standard. A Raytheon precision survey fathometer with narrow beam transducer (3 degrees) side mounted on the boat and the GPS antenna attached on top of the transducer are used to survey the forebay bottom. Sound waves transmitted by the transducer are reflected from the bottom and converted to sounding depth (Z), which is sent through the communication port to the Trimble GPS receiver module every second. The Trimble receiver collected recorded GPS position (X and Y) every second and accepted. The sounding depth from the fathometer and collected data are stored into the Trimble Data logger. Any sounding depth and recorded GPS position that are not synchronized in time will be discarded after post processing in the office. In order to guide the boat in North-South or East-West directions, second Trimble Pro-XR unit is used to guide the boat for navigational purposes.

The sounding depth and GPS position are recorded every second or approximately every 5 feet distance at 4 to 5 miles per hour boat speed. Bathymetry accuracy is estimated at +/- 0.3 foot error in sounding depth incurred due to wind, water current, vegetation under water and instrumentation errors.

6.2.3 Surface Elevation Changes/Sedimentation

Purpose: To meet the project goals of restoring tidal marsh, sedimentation must occur within the subsided Blacklock property. As suggested in the conceptual model developed for the Blacklock restoration site, initiating or altering the driving forces (tidal exchange, sedimentation) will move a site from its initial conditions (managed wetland) along a successionary trajectory toward tidal marsh associated habitats. For example, initiating tidal action by breaching the levee can result in sediment accretion if the sediment load is adequate, given the depth of the site. Assuming sufficient sediment exists, the pond bottom elevation will increase, eventually to the point when vegetation can colonize. The vegetation will help capture more sediment and will further build the marsh plain with dead plant material. Thus, restoring a vegetated marsh requires raising the elevation of a managed wetland pond to the level at which native vegetation can invade and/or spread.

Naturally deposited sediment aided by accumulation of plant detritus forms the substrate that is essential to plant establishment and growth and it provides the environment required by benthic organisms. The original constructed breach location was selected in part because of its proximity to Little Honker Bay. It is expected that Little Honker Bay will provide a sediment source for the Blacklock restoration site.

Methods: Sediment accumulation on the site will be monitored with Surface Elevation Tables (SET's) installed and periodic point surveys. The point surveys, at fixed locations will be conducted periodically to assess elevation changes.

Three SET's have been installed at various locations throughout the site (Figure 4). The SET's were placed in three distinct habitat types throughout the site. One was placed within emergent vegetation in the southwest area of the parcel, a second was placed in an existing pond, and the third placed in a slightly higher area within a large area of salt grass, near the northeast corner of the parcel.

Vertical accretion of sediments will be measured and compared with baseline data that was collected prior to the breach. The SET (Calhoun et al, 2002) consists of an arm temporarily inserted into a survey rod secured in a concrete filled PVC pipe. Pins are then inserted through a plate on the arm and successive measurements track changes in marsh surface elevation relative to the base of the pipe. A sampling structure was constructed at each SET location prior to inundation to prevent disturbance of the surface where measurements are made. To account for possible settlement of the SETs themselves, which may occur because the weight of the concrete used to install them could cause them to sink in the soft peat soils, the benchmark on each SET was surveyed to a known nearby benchmark at each SET measurement event.

Baseline SET measurements were collected during April 2006 and again in September 2006. Subsequent measurements will occur at approximately 6 month intervals. USGS established protocol will be followed for reading the SET's. It is expected that SET data will be collected at 6 month intervals, unless sedimentation data indicates that readings should occur more or less frequently. SET data will be collected until elevations stabilize on the site.

In addition to SET measurements, feldspar marker horizons were installed at each SET and cryogenic core samples will be extracted from the feldspar locations. Samples will be extracted at each 10 cm deposition interval up to 30 cm of deposition as measured by the SET. Data from the SET and feldspar marker horizons together allow for direct measurements of sediment accretion at the site.

Data to be gathered would be roughly 6 topographic transects (exact number to be determined) that cross the variety of baseline topographic conditions at the site and also reflect the gradient of distance from the levee breaches. Each transect would be monumented with 2" UV-resistant PVC markers at each end and at up to 2-3 points internally; each marker would facilitate reoccupation of the same transect line with repeat surveys and those markers on the marsh plain can serve double duty as sediment pins. Ground survey points would be collected at points of changes in slopes and intermittently along uniform areas. Topographic surveys would be performed with either a laser total station with surveys referenced to the existing on-site benchmarks (at WQ station and well pad) that themselves would need to be verified every few years, or by kinematic GPS that ties into benchmarks at the site and nearby. Topographic data will be compared with the 2002 survey (pre-project baseline) to evaluate elevation changes on the site.

If additional funding can be secured, DWR could conduct a sediment transport modeling study at Blacklock to look at the restoration processes at this site. An understanding of sediment transport and accretion are fundamental to wetland restoration: Wetlands can be rebuilt only if there are abundant sediment supply and a favorable hydrodynamic and sediment transport pattern for sediment accretion. Therefore, questions that relate to the source and the quantity of sediment (e.g., where the sediment comes from and if there is enough quantity to rebuild the wetland), the nature of sediment transport (e.g., how sediment concentration is distributed spatially and how it varies with time when a restoration action such as a levee breach is made), and the erosion and deposition potential (e.g., whether erosion or deposition will occur and if yes, how the erosion and deposition varies spatially and what the erosion and deposition rates will be) are of great concerns to wetland restoration processes. A sediment transport modeling study will provide answers to these questions and would be beneficial both at Blacklock and on a more regional scale.

6.2.4 Slough Network Evolution

Purpose: The restored area would include a slough channel network to support the diverse fish and wildlife communities expected to use the restored tidal marsh. In addition, an effective slough network is necessary to maintain the hydrology on site and support tidal exchange throughout the property.

While there is an existing slough network on the site, the location of the breaches may result in flows altering the configuration of sloughs within the property and these sloughs are all many feet below marsh plain elevations. Changes in the slough network will be monitored using aerial photography. Parameters to be measured include total surface area of channels, areas of expansion and loss, and changes over time.

Methods: Changes in the slough network will be monitored using aerial photography. Parameters to be measured include total surface area of channels, areas of expansion and loss, and changes over time. The site will be flown in conjunction with vegetation monitoring when practical (year 3). Aerial flights in years 1 and 2 will be scheduled for a similar time and phenological congruence as flights for the Suisun Marsh triennial vegetation surveys. This is typically the low tide in mid-June. Photos will be orthorecitified. GIS tools will be used to extract the channel network and to compare network planform geometry over time. Aerial photo interpretation will be verified in on-site.

6.2.5 Native Marsh Vegetation Development

Purpose: Vegetation development will be monitored to assess if native tidal marsh vegetation develops consistent with the performance criteria developed for this project. Plant community evolution will be measured a change in percent cover of vegetation classifications over time.

While there is extensive native marsh vegetation currently on the site, it is expected that some of that will die off as a result of inundated conditions. Since the property has been inundated, the saltgrass has been submerged and has died off. The pickleweed areas were also submerged. It is expected that some of the emergent vegetation will survive inundation and continue to colonize throughout the site, including those areas previously dominated by saltgrass and pickleweed. The die off of vegetation as a result of inundation will provide material for substrate formation. It is expected that sedimentation and detritus accumulation will contribute to an increase in site elevations and that vegetation will colonize as land surface elevation increases. Eventually, the vegetation will transition to a mix of species suited to the intertidal brackish environment.

Methods: In an effort to maintain consistency with regional data collection programs, the survey methodology established for the Suisun Marsh Vegetation Survey (DFG 1999 and 2003) will be used to measure vegetation changes at the site. This survey, developed by the DFG's Wildlife Habitat Analysis Branch (WHAB), blends ground-based classification, aerial photo interpretation, and GIS editing and processing. The method is based on the development of a quantitative vegetation classification, which is used to describe the vegetation map units of the marsh. Since this survey was initiated, updates to the protocol have been implemented to improve survey accuracy. These updates include adding an additional step to rectify the existing polygons to the new base image and interpret vegetation units utilizing a heads-up digitizing approach. If and when additional updates to the survey are implemented, they will be incorporated in the surveys at Blacklock.

Vegetation monitoring will consist of digital and field examination of rectified aerial photos. Vegetation monitoring as part of the 10 year monitoring plan is proposed for years 1, 3, 6, 9, and 10. During the years that the tri-annual vegetation survey is being conducted (years 3, 6, 9), this monitoring will utilize the aerial surveys and interpretation from the marshwide flight. Evolution will be measured as a change in percent cover of vegetation classifications over time, as described in the Suisun Marsh Vegetation Survey.

Consistent with the methodology developed by the WHAB of DFG, the property will be mapped and polygons will be inscribed for areas that appear uniform in color, texture, shadowing, and pattern on the photo. The polygons are interpreted for species composition, percent cover, height, and disturbance. Similar photo signatures are given the same code values. The classification system was developed from the original marshwide survey conducted in 1999 where a total of 139 vegetation categories were identified from 201 field observations. An accuracy assessment was performed on a randomly selected set of approximately 200 polygons during the fall of 2000.

All of the polygons are recorded electronically, or digitized, by tracing the patterns on the screen. Attributes are entered for each polygon into an Access database. When all the data are entered, the attributes are linked to the polygons using a unique polygon number as the key field. All of the field samples are processed through a statistical computer model known as clustering. This process groups field observations with similar vegetation characteristics, and forms the basis for the classification system.

Ground verification at the Blacklock site will be conducted each year the aerials are shot. Because of the accuracy needed to detect change at a smaller scale, field verifications to verify the accuracy of the polygon attributes will be more extensive at Blacklock than those conducted as part of the marshwide survey.

In addition, 6 photo stations will be established throughout the site to allow for photo documentation of vegetation development. These stations will be marked with PVC and the locations will be recorded with a hand held GPS. Photos will be taken annually at low tide.

6.2.6 Wildlife

Purpose: The SMPA Environmental Coordination Advisory Team (ECAT) anticipates that restoration of Blacklock to tidal marsh will provide long-term ecological benefits to tidally dependent wildlife species. It is expected that habitat will be available for waterfowl and shorebirds. However, it is anticipated to take several years of sediment accretion for marsh elevations to raise enough to provide habitat for terrestrial species. Once surface elevations rise, and vegetation colonizes, it is expected that Blacklock will develop into a fully functioning tidal marsh with suitable habitat for marsh dependent wildlife species, including black rails and salt marsh harvest mice.

Some groups of waterbird species are expected to make use of the site during the early period (soon after breaching) and other waterbird species are expected to use the site later during the restoration process (e.g., shorebirds such as avocets and stilts, and waterfowl, such as dabbling ducks; Stralberg et al. 2004).

PRBO Conservation Science and the SMPA agencies conducted a study of bird habitat use in Suisun Marsh during 2004. This survey was funded under the Bay-Delta Consortium small grants program. Six sites were surveyed for birds several times a year, and estimates were made of the numbers of each species using each site, at what time of year, which parts of the site or features of the site each species responds to. Blacklock, was one of the sites included in the survey. This provides an opportunity to look at species composition at Blacklock as both a managed and tidal wetland.

6.2.6.1 Avian Monitoring

Methods: Waterfowl and shorebird uses of the Blacklock restoration will be conducted. These surveys will begin within one year of breaching and will continue quarterly at both low and high tide to track shorebird and waterfowl use of the ponds. DWR staff will conduct the surveys, with assistance from other agencies if needed.

Both tidal-marsh dependent birds, which includes, black rail, song sparrow, common yellowthroat, and marsh wren, will be monitored, as well as other bird groups, mainly waterbird species, are expected to make use of habitat at this site during the restoration period, either early or late. This site is thought to be too far east to support California clapper rail; therefore, CCR specific surveys will not be conducted.

Survey methods and protocols are consistent with those described by the Wetlands Regional Monitoring Program (WRMP 2002), are similar to those used by the IRWM program (www.irwm.org), and consistent with those used by PRBO in their previous surveys at the site.

At Blacklock, two types of surveys will be conducted, point count and specialized surveys for black rail. A Point count survey is a generic method intended to survey all bird species using a site, the second method is specialized surveys intended only for the specified species. Point count surveys are intended to be conducted in all habitats.

Point count surveys: Point count stations (survey observation points) will be established at about 10 locations, both along levees and in the site. For the Blacklock site, point count locations have already been established and survey data has been collected in the past by PRBO. It would be desirable to retain these locations as much as possible. Surveys are conducted 4 times per year.

Black rail surveys: Surveys will be conducted twice per year, in April and May, following standardized procedures (Evens et al. 1991, WRMP 2002). Black rail surveys will be conducted at each point count survey station (see above), for sites with possible rail habitat.

6.2.6.2 SMHM surveys

Methods: The Blacklock property was proposed, and will be included as part of the 2500 acres designated at “conservation” areas in Suisun Marsh, pending USFWS approval. SMHM monitoring at Blacklock will be conducted as part of the long-term SMHM monitoring program implemented on the conservation areas. Future monitoring at Blacklock will be consistent with any approved updates to the marshwide SMHM monitoring program.

Currently, the approved protocol calls for these areas to be surveyed once every three years. However, this plan is being reviewed through the SMPA ECAT process.

Habitat on the levees and in the pond will be assessed annually. Due to tidal inundation of the pond, it is expected that potential SMHM habitat will be present only on the levees. Recent surveys have captured very few SMHM on the levees. Until suitable habitat begins to develop in the pond, SMHM surveys will be conducted only on the levees. Once habitat begins to develop in the pond, surveys will be conducted in these areas if they can be done in a way that does not adversely affect the developing vegetation. Trapping protocols will be similar to protocols used by DWR and DFG in their existing marsh wide SMHM surveys.

6.2.7 Fish

A monitoring program for aquatic resources would only be implemented if additional funding is secured. SMPA ECAT is pursuing additional funding options; however, there is currently no secured funding source for aquatic monitoring. The following proposal (currently unfunded) describes evaluating primary productivity at the site. Actual aquatic monitoring conducted at Blacklock would reflect the specific proposal approved and funded.

Purpose: A proposal for evaluating primary productivity at the restoration site suggests that the Blacklock restoration project is anticipated to support native fish species including chinook salmon, delta smelt and other pelagic organisms by increasing the production of nutritionally valuable phytoplankton and zooplankton. Evidence supports the hypothesis that due to their unique geomorphic and hydrodynamic characteristics, tidal wetlands provide abundant and high quality physical habitat and food resources for the native species that coevolved with them, while being less favorable habitats for at least some of the invasive and noxious species that have become established over the last decades and centuries (*e.g.* Aheran et al 2006, Crain et al 2004, Sommer et al 2004, Brown 2003, Matern et al 2002, Müller-Solger et al 2002, CALFED 2001). In addition, frequent flooding and draining events stimulate diverse exchange processes with surrounding systems and provide a highly variable and complex habitat spectrum for aquatic organisms (Tockner et al 2000A, B; Ward and Tockner 2001). Recent studies (Cloern, 2007; Lopez et al 2006) have shown that shallow autotrophic habitats can export algal biomass and fuel secondary production in adjacent deep heterotrophic habitats, but only if these habitats are properly connected. An understanding of the magnitude of fish food production and release from restored tidal marshes in Suisun Marsh is critical to determining the ability of restored intertidal marshes to aid in the recovery of pelagic species such as delta smelt.

Proposed methodology: The study incorporates a replicated repeated-measures analysis of variance experimental design. Data would be collected on the following amounts and process rates. Results would be evaluated using statistical and numerical modeling approaches

- Phytoplankton growth, production, biomass, abundance, composition, and grazing rates
- Zooplankton growth, production, biomass, abundance, composition, and grazing rates
- Benthic growth, production, biomass, abundance, composition, and grazing rates
- Vascular plant production, biomass, cover and composition
- Fish densities
- Bird use (separately funded study)
- Nutrient concentrations and dynamics (uptake, regeneration, etc.)
- Concentrations and dynamics of other water quality variables including
    - Dissolved oxygen
    - Organic carbon fractions
    - Salinity
    - Turbidity

- o Temperature
- o Methyl mercury (separately funded study)

Aquatic monitoring would be integrated as much as possible with other actions aimed at species recovery in the marsh. The detailed design of the monitoring plan could be undertaken by an interdisciplinary, interagency monitoring team. The plan would be reviewed by other scientists and managers of the marsh science and resource management community and potentially by independent reviewers from elsewhere in the U.S. A review team composed of ecologists, engineers, and agency resource managers from various agencies and universities would be formed. The team would provide advice on monitoring and help with 'adaptive modifications' of the monitoring program. The team would also ensure monitoring is coordinated with other monitoring programs (in terms of procedures and protocols, and timing), would take advantage of existing monitoring programs and data, and would be responsible for integrated reporting, analysis, and interpretation of data. The team would also be responsible for communicating the results and interpretations to IEP and CALFED programs and agencies, other scientists, and other interested entities.

6.2.8 Water Quality

Purpose: Hydrodynamic modeling conducted by DWR suggests that breaching levees in Suisun can affect salinities both in Suisun Marsh and in the Sacramento-San Joaquin Delta. The specific effects are dependent on the size and location of the breach and the area of inundation. Modeling of the Blacklock restoration shows changes in salinity in Montezuma Slough, both upstream and downstream of Nurse Slough; however, these changes are minor and are not expected to impact DWR's ability to meet SWRCB salinity standards for Suisun Marsh. DWR will continue to collect salinity data at the BLL monitoring station adjacent to the restoration. In addition, salinity data is continuously collected at the other compliance and monitoring stations in Suisun Marsh as part of SWRCB D-1641 requirements.

Methods: The BLL monitoring station collects precipitation, water temperature, wind speed and direction, atmospheric pressure and stage every 15 minutes and transmits data to CDEC on an hourly basis. In early 2006. a pressure transducer was installed on the pond side of the levee to monitor tide stage within the site. Data is telemetered to CDEC so tide stage can be monitored remotely.

Modifications to the existing BLL station were made in May 2007 to facilitate the collection of water quality data within the restoration area. Temp, DO, EC data are now collected. Stage data has been collected at this location since early 2006. A walkway was installed over the borrow ditch and a new multi-parameter water quality monitoring probe (YSI 600 OMS with an ROX optical oxygen sensor was installed). The existing BLL site will be retrofitted with the same sensor to compare dissolved oxygen data in the slough with what is collected within the restoration site. A USACE nationwide permit #5 (scientific monitoring) and 401 water quality certification were obtained to authorize the retrofit of the existing monitoring station and install the probe. Currently, only stage and DO from within the restoration area are telemetered to CDEC. Additional equipment would need to be installed at the site to telemeter all of the parameters collected on the inside. All of the data is downloaded when the station is serviced (every two – four weeks) and stored in the Suisun Marsh database.

Dissolved oxygen levels would be expected to be much lower at this location because it is located at an area of the property with low water circulation. EC, DO and temperature is collected in 15 minute intervals. will be continuously collected (15 minute). , and data will be telemetered to the CDEC.

Temperature, EC and DO may also be collected in other areas of the restoration site as part of any future fish monitoring (pending additional funding).

6.2.9 Methyl Mercury

Purpose: Water quality changes, specifically changes in salinity and the production of methyl mercury, resulting from tidal inundation at Blacklock are of particular interest to agencies involved in long term planning decisions in Suisun Marsh. While tidal wetland areas in Suisun Marsh and the Delta have been shown to be high producers of methyl mercury, production of methyl mercury in the managed seasonal marshes has not been well documented. Therefore, the impact of restoration of managed seasonal wetlands on methylmercury production is unknown.

This property, while not managed as a “typical managed wetland” provided an opportunity to investigate methyl mercury production before and after tidal inundation. Although limited, data was collected at Blacklock prior to the levee breach. DFG collected water samples during one field event in February, 2005. Very high methyl mercury concentrations (up to 2.3 ng/L) were observed during this sampling event, when water was collected after the levee overtopped and the pond was full. Nurse Slough, the wetland adjoining Blacklock, was observed to have significantly lower methyl mercury concentrations (up to 0.07 ng/L) in water collected July, 2004.

The pre-breach sampling efforts for water, biota, and sediments were funded under the existing CALFED grant. Since the San Francisco Bay RWQCB is in the process of developing the mercury total maximum daily load (TMDL), the sampling plan could be revised in the future if standardized protocols are developed to support this effort.

Methyl mercury is produced during bacterial reduction of sulfate in surficial sediments, thus the likely source of methyl mercury to overlying water in Blacklock is flux from the sediments. When the breach occurs water and suspended sediment from in Blacklock will likely be exchanged with water and suspended sediment originating in Nurse Slough/Little Honker Bay. Methyl mercury concentrations in Blacklock could decrease or increase as a result of the breach.

Methods: Mark Stephenson, DFG Moss Landing is investigating methyl mercury issues in Suisun Marsh as part of a CALFED funded study and has developed a methyl mercury monitoring program for the Blacklock Restoration Project. The DFG monitoring program proposes the following sampling plans to analyze water, sediment and tissue pre- and post- breach to assess the changes in methyl mercury associated with full tidal inundation at the site.

Proposed Sampling Plan specific to hypothesis 1- Sediment concentrations in Blacklock will decrease post breach relative to pre breach concentrations. Sediment samples will be collected at 10 sites in Blacklock before the breach then at 6, and 12 months post breach. Sample mercury, methyl mercury, grain size and organic carbon at specific depths (0-5). Sampling will be based on a stratified random design that stratifies according to elevation, sediment and vegetation type. Total and methyl mercury will be analyzed.

Proposed Sampling Plan specific to hypothesis 2 - Methyl mercury in biota will decrease in Blacklock post breach Sample resident fish species in Blacklock and Nurse Slough pre- breach and 12 months post- breach.

Proposed Sampling Plan specific to hypothesis 3 - Blacklock is a source of mercury (water samples). Methyl and total mercury will be measured at 6 locations throughout the Blacklock property and 3 locations in the Nurse/Denverton/Little Honker Bay vicinity. Grab samples will be collected pre breach and 1, 3, 6, and 12 months post breach. Samples will be analyzed for total and methyl mercury and TSS.

If additional funding is secured (directed studies, other grants), this sampling program could be expanded.

6.2.10 Erosion of Adjacent Sloughs

Purpose: The increased tidal prism of the site is expected to cause scour bayward of the breaches over time until those waterways achieve a new equilibrium. Little Honker Bay is a large water body and its response to the tidal prism change may be more localized to breach location. Arnold Slough is more confined and if a breach is constructed (or occurs naturally) at a later date, then it may show a larger area of scour.

Methods: Pre-breach bathymetry surveys were conducted in September 2006 at both the Little Honker Bay and Arnold Slough proposed breach locations (Figure 2). A post-breach survey was conducted on October 17, 2007 (shortly after breach construction). Additional bathymetry surveys will be conducted in conjunction with any additional cross sectional surveys made of the existing or future natural breaches (see task 2). The need and timing of additional cross sectional profiles of the breaches will be dependent upon observed changes of the breach and an evaluation of tidal inundation (see task 3).

If a second breach is constructed in Arnold Slough, pre –and post- breach bathymetric surveys would be conducted using the same methodology.

Breach cross section and bathymetry data is collected from a 16-foot aluminum boat using a Trimble Pro-XR GPS/Beacon receiver with integrated GPS/MSK Beacon antenna utilizing a real time DGPS (differential GPS) receiver module and a fully automatic, dual-channel MSK beacon receiver module for receiving DGPS broadcasts conforming to IALA (International Association of Lighthouse Authorities) standard. A Raytheon precision survey fathometer with narrow beam transducer (3 degrees) side mounted on the boat and the GPS antenna attached on top of the transducer are used to survey the forebay bottom. Sound waves transmitted by the transducer are reflected from the bottom and converted to sounding depth (Z), which is sent through the communication port to the Trimble GPS receiver module every second. The Trimble receiver collected recorded GPS position (X and Y) every second and accepted. The sounding depth from the fathometer and collected data are stored into the Trimble Data logger. Any sounding depth and recorded GPS position that are not synchronized in time will be discarded after post processing in the office. In order to guide the boat in North-South or East-West directions, second Trimble Pro-XR unit is used to guide the boat for navigational purposes.

The sounding depth and GPS position are recorded every second or approximately every 5 feet distance at 4 to 5 miles per hour boat speed. Bathymetry accuracy is estimated at +/- 0.3 foot error in sounding depth incurred due to wind, water current, vegetation under water and instrumentation errors.

6.2.11 Control of Invasive Plant Species

Purpose: Colonization of the Blacklock restoration site by non-native invasive plant species would jeopardize meeting the objectives of the restoration. Many of the important ecological benefits of restored tidal marsh vegetation will not be provided by invasive species. Specifically, colonization by invasive non-native plant species may prevent establishment of native tidal marsh vegetation.

Monitoring and control of non-native invasive plant species will focus on two invasive plants that are particularly problematic in Suisun-*Phragmites australis* and perennial pepperweed (*Lepidium latifolum*). Lepidium is a problem throughout Suisun marsh, however, it has not been found at Blacklock to date. When and if pepperweed is found on the site, control methods, including herbicide use, may be employed to prevent its establishment at the site. DWR staff will consult with weed management specialists to identify the most appropriate control method.

The spread of phragmites is a problem throughout Suisun Marsh and control experiments are ongoing. As in other managed wetlands, populations of phragmites have become established at Blacklock. The depth and duration of flooding with tidal inundation may help control the spread of this species (FWS, 1989). Monitoring will be conducted annually to determine any changes in phragmites cover. Alternative treatment techniques may be employed to control the spread of this species, if needed.

Methods: Surveys for non-native invasive plant species will be conducted at the beginning and the end of the growing season. In addition, field personnel will be encouraged to report any occurrences of pepperweed to weed control specialists for immediate treatment, if appropriate. To control pepperweed, DFG has initiated a pilot program to use Chlorsulfuron (Telar) in tidally influenced areas. The Although Telar is approved for use in tidally influenced areas only above the Mean High Tide line, the DFG study applied Telar (1% and 2 %) in areas where the area above the Mean High Tide line would not be inundated for at least 24 hours. Those times usually occurred in May and September. The May spraying coincided with the plants being in the bud stage which has been shown to be one of the most effective times to spray. DFG reported that the 1% solution to be almost as effective as the 2%, but because of the difficulty of access to the sites they used 2% to make sure they maximized the effectiveness of the spray effort. (Sarah Estrella, DFG, pers com, 7-24-2006)

The need for treatment and the associated costs of such treatment is highly variable and dependent on the presence and extent of non-native invasive species (NIS) at the site. Treatment, and the expenditure of the estimated funds would occur to aggressively address NIS on an as-needed basis.

6.3 Monitoring Reports

Monitoring reports describing the data collected and any adaptive management actions will be submitted to BCDC for the duration of the 10 year monitoring plan. Reports will be submitted every two years, beginning on December 1, 2008, two years following the completion of restoration activities. Monitoring reports will be available on-line at http://iep.water.ca.gov/suisun/restoration/blacklock/

Any reporting requirements specified as part of securing additional funding will be followed.

Regular updates on project implementation and monitoring will continue to be presented at SMPA ECAT meetings.

6.4 Survey Methodology and Quality Assurance/Quality Control

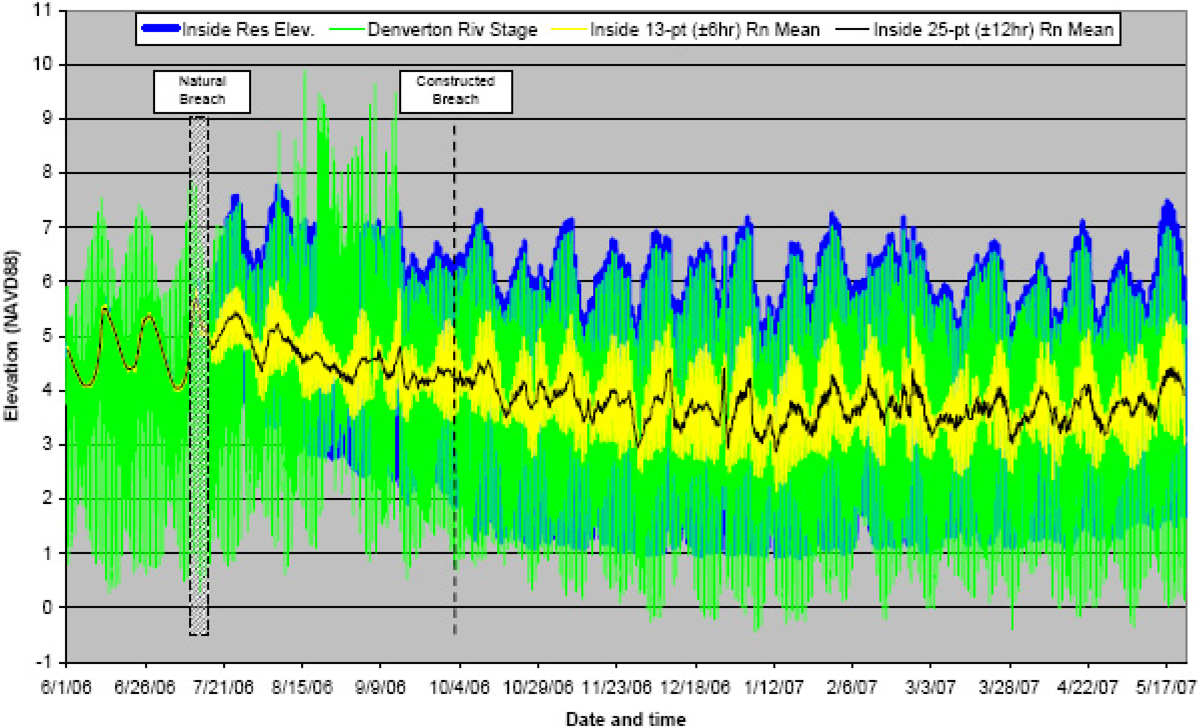
All data collection and analysis will follow Interagency Ecological Program QA/QC requirements (IEP 1999) unless otherwise specified in this document.

Table 7 - Restoration Monitoring Schedule

Section	Description	Year(s) for Each Monitoring Activity 1	Frequency During Years Monitored	Seasonal Timing
5.2.1	Inundation regime	Years 1, 2, 3, 5, 10	Continuous	Spring Tides (Jun - Jul or Dec - Jan)
5.2.2	Levee breach and outboard marsh channel geometry[3]	Years 1, 2, 3, 5, 10	Annual	With air photo
5.2.3	Substrate development SET measurements	a) Years 1- 3 b) Year 4 to 25% native veg. cover	Semiannual Annual	winter, summer summer
		c) Begin at 25% native veg. cover, end at 75% native veg. cover	Once every 3 years	summer
	Substrate development Topographic Surveys	a) Years 1- 3 b) Year 4 to 25% native veg. cover	Semiannual Annual	winter, summer summer
		c) Begin at 25% native veg. cover, end at 75% native veg. cover	Once every 3 years	summer
5.2.4	Channel network evolution	Years 1, 2, 3, 5, 10	Annual	With air photo and topographic surveys
5.2.5	Calculate veg. percent cover from air photo and ground truthing	a) Year 1 to 35% native veg. cover	Annual	Jul - Aug
		b) Begin at 35% native veg. cover, end at 75% native veg. cover	triennial	Jul - Aug
	Vegetation field surveys (transects and plots)	Begin at 25% native veg. cover, end at 75% native veg. cover	triennial	Jul - Aug
5.2.6	Invasive plant species establishment	Year 1 to 75% native veg. cover	three times per year	spring, summer, fall
5.2.7	Water Quality in adjacent sloughs/LHB (hydrodynamics, sediment, chlorophyll)	Baseline sampling prior to breach Continue through inundation, end at stable results	Continuous	
	Water Quality In adjacent sloughs/LHB (hydrodynamics sediment, chlorophyll, methylmercury)	30 hour drifter studies	pre breach post breach	TBD
	Water Quality (methylmercury)	Baseline sampling prior to breach Begin at inundation	TBD[2]	
5.2.8	Fish Occurance	Begin year 2 after inundation	Annual	TBD
	Fish Site Function	Begin year 3 after inundation	Annual	TBD
5.2.9	Wildlife use (SMHM)	Begin at inundation on levees, survey available suitable habitat, end when stable survey results achieved	Annual	Jun - Aug
	Wildlife use (shorebirds & waterfowl)	Years 1, 3	Quarterly	Win, Spr, Sum, Fall
	Wildlife use (shorebirds & waterfowl)	Years 5, 10	annually	TBD

Notes
1. Projected time estimates to achieve Performance Criteria, actual duration is dependent upon Performance Criteria (see Restoration Performance Criteria, Section 5.1).
2. Sampling protocols to be developed by Mark Stephenson, CDFG

Figure 27: Hourly Water Level Data at Blacklock from June 01, 2006 to May 22, 2007



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APPENDIX A

Conceptual Model for the Blacklock Tidal Marsh Restoration Plan Implementation

Revised May, 2007

APPENDIX A

Conceptual Model for the Blacklock Tidal Marsh Restoration Plan Implementation

Revised May, 2007

I. The goals for the Blacklock Tidal Marsh Restoration are as follows:

1. Increase the area and continuity of tidal brackish emergent wetlands in Suisun Marsh to aid in the recovery of listed and sensitive species, and

2. Acquire scientific knowledge regarding ecosystem function that leads to improved understanding of tidal marsh restoration processes, strategies, and ecological outcomes within Suisun Marsh.

II. Guiding Principles for the Blacklock Restoration Plan

1. The restoration plan is based on the best available science, and independent scientific review is an integral part of its development and implementation.
2. Numerous federal, State and local agencies are partners in the restoration plan and their views are considered fully.
3. The restoration plan is a flexible plan that is based on the concept of adaptive management – recognizing that information gathering is part of implementation and that modifications will be made in the future based on that information.
4. Development of the restoration plan will consider costs of implementation and monitoring so that planned activities can be effectively executed with available funding.
5. The restoration plan emphasizes naturally sustaining systems and the supporting ecological processes.
6. The partners in the restoration plan recognize that any one restoration design may not meet the needs of all resources, especially where resource needs are competing.

III. Blacklock Restoration Project Objectives

Restoration objectives: restore the Blacklock property to functioning brackish tidal marsh by restoring tidal action and using a minimal engineering approach to reverse subsidence, and promote establishment of native vegetation and a tidal marsh channel network appropriate to this location and intertidal elevation within the San Francisco Estuary (DWR 2006).

Science objectives: allow for and encourage collaborative science opportunities in the project design and monitoring phases that supports regional adaptive resource management needs.

APPENDIX B

Blacklock Restoration Project Work Team

Steven Chappell	SRCD	ECAT, interim management, maintenance
Janice Engle	FWS	ESA, wildlfife and fisheries
Chris Enright	Ca DWR	Hydrodynamics, sediment transport
Cassandra Enos	Ca DWR	ECAT, Fisheries, Interim Management
Terri Gaines	Ca DWR	Project management, plan devel, permitting, etc.
Jeff Hart	Hart Restoration	Revegetation, brush boxes
James Kulpa	WWR	Surveying, SET
Leonard Liu	PRBO Cons. Science	Avian surveys
Nadav Nur	PRBO Cons. Science	Avian surveys
Laura Patterson	Ca DWR	Wildlife, SMHM
Michael Perrone	CaDWR	Wildlife, Avian surveys
Patty Quickert	Ca DWR	ECAT Wildlife, SMHM trapping
John Robles	formerly USBR	ECAT, NEPA
Leonard Sklar	SFSU	Sediment availability and transport
Randall Smith	Ca DWR	Surveying
Mark Stephenson	Ca DFG	methyl mercury
Jim Sung	Ca DWR	Levee maintenance, design, repair
Mary Snow	SFSU	Sediment availability
Bruce Wickland	SRCD	Interim management, maintenance
Jean Witzman	Ca DWR	Vegetation, invasive species control
Xiaochun Wang	Ca DWR	Modeling

APPENDIX C

Blacklock Restoration Advisory Team

Project Manager
Terri Gaines
Staff Environmental Scientist
California Department of Water Resources

Science Advisor
Dr. Stuart Siegel
Wetlands Ecologist
Wetlands and Water Resources

Hydrodynamic Modeling, Water Quality, Sediment Transport
Christopher Enright
Senior Engineer
California Department of Water Resources

Sediment Availability and Transport
Dr. Leonard Sklar
Professor of Geoscience
San Francisco State University

Fisheries, Interim Management
Cassandra Enos
Staff Environmental Scientist
California Department of Water Resources

Interim Management Advisor, Levee Maintenance
Steven Chappell
Executive Director
Suisun Resource Conservation District

Wildlife
Laurie Briden
Wildlife Biologist
California Department of Fish and Game

NEPA, permitting
John Robles
Environmental Specialist
U.S. Bureau of Reclamation

Wildlife, Fisheries, ESA
Janice Engle
Biologist
U.S. Fish and Wildlife Service

APPENDIX D

U.S. Fish and Wildlife Service Species List
Document # 060330024152

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

March 30, 2006

Document Number: 060330024944

Terri Gaines
Ca Department of Water Resources
3251 S Street
Sacramento, Ca 95816

Subject: Species List for Blacklock Restoration Project

Dear: Ms. Terri Gaines

We are sending this official species list in response to your March 30, 2006 request for information about endangered and threatened species. The list covers the California counties and/or U.S. Geological Survey 7½ minute quad or quads you requested.

Our database was developed primarily to assist Federal agencies that are consulting with us. Therefore, our lists include all of the sensitive species that have been found in a certain area *and also ones that may be affected by projects in the area*. For example, a fish may be on the list for a quad if it lives somewhere downstream from that quad. Birds are included even if they only migrate through an area. In other words, we include all of the species we want people to consider when they do something that affects the environment.

Please read Important Information About Your Species List (below). It explains how we made the list and describes your responsibilities under the Endangered Species Act.

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be June 28, 2006.

Please contact us if your project may affect endangered or threatened species or if you have any questions about the attached list or your responsibilities under the Endangered Species Act. A list of Endangered Species Program contacts can be found at www.fws.gov/sacramento/es/branches.htm.

Endangered Species Division

TAKE PRIDE IN AMERICA

Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species
that Occur in or may be Affected by Projects in the
DENVERTON (481B)
U.S.G.S. 7 1/2 Minute Quad
Database Last Updated: March 1, 2006
Document Number: 060330024152

Listed Species

Invertebrates

Branchinecta conservatio - Conservancy fairy shrimp (E)
Branchinecta conservatio - Critical habitat, Conservancy fairy shrimp (X)
Branchinecta lynchi - Critical habitat, vernal pool fairy shrimp (X)
Branchinecta lynchi - vernal pool fairy shrimp (T)
Desmocerus californicus dimorphus - valley elderberry longhorn beetle (T)
Elaphrus viridis - Critical habitat, delta green ground beetle (X)
Elaphrus viridis - delta green ground beetle (T)
Lepidurus packardi - Critical habitat, vernal pool tadpole shrimp (X)
Lepidurus packardi - vernal pool tadpole shrimp (E)

Fish

Hypomesus transpacificus - Critical habitat, delta smelt (X)
Hypomesus transpacificus - delta smelt (T)
Oncorhynchus mykiss - Central Valley steelhead (T)
Oncorhynchus tshawytscha - Central Valley spring-run chinook salmon (T)
Oncorhynchus tshawytscha - winter-run chinook salmon, Sacramento River (E)

Amphibians

Ambystoma californiense - California tiger salamander, central pppulation (T)
Rana aurora draytonii - California red-legged frog (T)

Reptiles

Thamnophis gigas - giant garter snake (T)

Birds

Haliaeetus leucocephalus - bald eagle (T)
Rallus longirostris obsoletus - California clapper rail (E)

Mammals

Reithrodontomys raviventris - salt marsh harvest mouse (E)

Plants

Cordylanthus mollis ssp. mollis - soft bird's-beak (E)
Lasthenia conjugens - Contra Costa goldfields (E)
Lasthenia conjugens - Critical habitat, Contra Costa goldfields (X)

Candidate Species

Fish

Oncorhynchus tshawytscha - Central Valley fall/late fall-run chinook salmon (C)

Oncorhynchus tshawytscha - Critical habitat, Central Valley fall/late fall-run chinook (C)

Key:

(E) *Endangered* - Listed (in the Federal Register) as being in danger of extinction.
(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.
(P) *Proposed* - Officially proposed (in the Federal Register) for listing as endangered or threatened.
(NMFS) Species under the Jurisdiction of the National Marine Fisheries Service. Consult with them directly about these species.
Critical Habitat - Area essential to the conservation of a species.
(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.
(C) *Candidate* - Candidate to become a proposed species.
(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, or may be affected by projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regard-less of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the quad or quads covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the nine surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All plants and animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compen-sates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our critical habitat page for maps.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6580.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be June 28, 2006.